SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXIX | MAY, 1939 | WHOLE NO. 340

THE 1939 CONVENTION

One of the fine things about the convention of the ***Central Association of Science and Mathematics Teachers*** is that it is always within reach of the majority of the members of that organization. Members do not have to wait until the meeting is in their part of the country to feel that they can afford to attend. They can and many do attend each year. At the same time, the association provides programs comparable to those of national educational groups whose conventions travel from coast to coast.

A meeting was held in Chicago, March 18, to consider the program for the 1939 convention of the ***Central Association*** which will be held in Chicago, December 1 and 2 of this year. Directors and chairmen of standing committees were invited to meet with the officers of the association and section chairmen at that time. It was decided by this group that the general plan of the program should be similar to that of last year, that is, a general program Friday morning, sectional programs Friday afternoon, a banquet program that evening and programs by grade level Saturday morning. Outstanding educators are now being invited to speak at these sessions.

The exhibitors have again been invited to present special demonstrations and two trips are being planned for Saturday afternoon, one to the Adler Planetarium and the other to the Museum of Science and Industry.

Further details of the convention will appear in this journal soon. Note on your calendar that you are due at the Morrison Hotel the day after Thanksgiving.

MARIE S. WILCOX,
President

A NEW SCIENCE PROGRAM IN THE MAKING

Ira C. Davis
University High School, Madison, Wis.

The president of a publishing concern asked me this question a few years ago, "Do you know how we rank school teachers and administrators?" Being curious, I said I would like to know. Then he answered his own question by saying, "We rank school teachers and administrators as ninety per cent talkers and ten per cent doers." I did not argue the question with him, but I thought possibly a little self-examination would do no harm.

After I have attended several conventions each year, I wonder how far we do get beyond the talking stage. I am not insinuating in the least that the talking is unnecessary or that it does interfere with progress in education. This question has been raised in my mind several times the past few years—does our present set-up of teacher organizations provide a democratic procedure for solving the many perplexing problems we have in science education today? No doubt all organizations are making some contributions to the solution of these problems. However, isn't there a great amount of duplication and lost motion? All organizations have about the same kind of programs at conventions. Quite often the same topics are discussed in several conventions in one year. If you study the convention programs of several organizations over a period of years, you will discover that series of topics seem to run in cycles. I heard an elementary science teacher say not long ago, "I have attended six conventions the last two years and all of them have had practically the same program."

I realize full well the social and educational advantages that come from learning to know a large number of science teachers. I value these friendships a great deal. But friendships and programs do not necessarily get us beyond the talking stage in education, and I believe if you visited a large number of classroom teachers in action, you could place most of them in two groups—those who teach and those who talk about teaching. But everywhere you hear teachers say they are becoming impatient. One day they hear this is the right way to teach. Then the next day someone else tells them that method is outmoded and probably never was right in the first place. But can we blame them for being impatient and hesitant to tackle new

problems? *Where could a group of science teachers go today to get help on science teaching and science education?* I mean help based on the carefully thought out plans of a large number of good teachers, plans developed through a careful and comprehensive study of the whole field of science education. Some of you, no doubt, will say, "Are you not criticizing the good work that has been done by a large number of individuals and small groups?" I have only praise for these good teachers who have laboriously conducted worthwhile investigations. The reports and books issued by them have caused people to think. These materials have caused teachers to question what they were doing. But they still leave us in the talking stage.

Isn't there some way we can make use of all the good talking we have been doing for years and proceed into the doing stage? By the doing stage I mean a program which is really reaching our boys and girls in every science classroom. Isn't it possible for us to construct a program in science education that will really function in all of our schools, both large and small? But you, no doubt, will say, "Who should do it?" My answer is—*all of us should do it.* This means classroom teachers and administrators at all school levels.

Some kind of an organization needs to be perfected for the undertaking of such a program. This organization must have enough educational support to give "drive" to its program when it is formulated. The program must be promoted by an organization, or organizations, in which teachers have confidence and respect. I have felt for some time that we did not have any one organization that could undertake such a program alone. The main obstacle is *finances.* I doubt if there is one elementary or secondary school science teachers association in the United States that can really afford to pay the expenses of one representative to the meetings of a committee for a period of two years. This is not a criticism of any of these organizations. They really have no possible ways of raising enough money to undertake such a program. Most of the money they do get is needed to take care of overhead expenses.

What organization is in a position to initiate such a program? I doubt that any of you will disagree with me when I say I believe the National Education Association should undertake such a program. The Association has approximately 200,000 members, is well financed, and has a forward looking program in the making. Two years ago the Department of Science In-

struction discussed the desirability of requesting the budget committee of the N.E.A. for funds to undertake this program. The Executive Committee and the general assembly approved the request at the meetings in New York last June. Mr. Givens, executive secretary of the Association, and Mr. Shaw, the president of the Association, and a science teacher, have given every possible help in getting the program under way.

The Department of Science Instruction invited all national organizations of science teachers to cooperate in developing such a program. In order to get organizations of proven stability, it was decided to limit the invitations to organizations which had had a continuous existence for at least five years. All district, local, and group organizations have been invited to select consultants to assist with general and special problems. The consultants are invited to attend meetings when it is possible for them to do so. It is hoped the consultants will be able to do at least two things: first, furnish the general committee with information and facts on science teaching in their organizations or districts; and second, consider and discuss with their organizations and groups the problems submitted to them by the general committee. At present 95 consultants have accepted the invitation to cooperate with the general committee. When the list is completed the total number should exceed 200. It should be understood one consultant represents a large number of teachers.

The membership of the National Science Committee was given on page 303 of the April issue of SCHOOL SCIENCE AND MATHEMATICS. This committee will direct the general plans for developing the program and will be assisted by a large number of very able consultants.

Several factors were taken into consideration in selecting members for the committee. Following are some of the factors:

1. Breadth of experience in the teaching of science.

2. Standing in the field of science education or education in general including the publications written.

3. Number of teachers to be reached for discussions and reactions. Organizations to be contacted.

4. Secretarial help available.

5. Freedom to attend committee meetings on school time without loss of pay to the member or an expense item to any organization.

6. Distribution both geographically and for the different school levels. Members come from ten different states and the District of Columbia.

The same general care has been taken in selecting the consultants. Practically every organization of science teachers in the United States is represented by a member of the general committee or by a consultant. The total number of consultants is 95. The total number of states represented so far is 42.

The committee held its first meeting at Cleveland on February 23 and 24. The two-day meeting was largely devoted to a discussion of problems in the field of science education. Dr. Palmer of Cornell University discussed problems of conservation; Dr. Teschler of the American Medical Association, problems of health; and Dr. Helen M. Strong of Washington, D. C., and Dr. C. Langdon White of Western Reserve University, problems in the fields of geology and geography. W. E. Givens and Reuben T. Shaw discussed the future plans of the Educational Policies Commission.

The committee's problem is to develop a program in science for grades one to fourteen inclusive. It agreed to a five-point attack on the problem. Sub-committees were selected to make a thorough study of science education through these five points.

Sub-committee on Philosophy or Frame of Reference: Nathan A. Neal, Chairman, Harold H. Metcalf, H. A. Webb.

Sub-committee on Present Day Needs of Boys and Girls: W. C. Croxton, Chairman, Florence G. Billig, Harry A. Carpenter.

Sub-committee on Evaluation of Methods and Results of Teaching: C. E. Preston, Chairman, M. V. McGill, E. S. Osbourn, W. R. Teeters.

Sub-committee on Teacher Education: S. R. Powers, Chairman, Florence G. Billig, Gladys F. Potter.

Sub-committee on Administration: Ira C. Davis, Chairman, Gladys F. Potter.

Each consultant has been assigned to one of these sub-committees. This means that each sub-committee has a good representation of science teachers for all school levels, for all subjects in science, and for all parts of the United States.

The members of the general committee and the consultants extend a most cordial invitation to all teachers of science to

cooperate in making this new science program. *This new program will not be any better than teachers make it. It will not be any better than teachers can teach it in the classroom.*

If you are interested in cooperating, please send your name to the writer or to any chairman of a sub-committee.

The next meeting of the committee and the consultants will be held in Hotel Cleveland, in Cleveland, May 12 and 13, 1939.

AN AID IN TEACHING PERCENTAGE COMPOSITION

H. F. Cope, *High School, Medford, Oregon*

Here is a model solution of a type of problem with which high school students in chemistry often struggle and often fail to solve. Most of us agree that percentage problems should be rather easy for the average student but results from tests do not always prove this to be so. The student may be able to eke out a solution by ordinary arithmetical analysis

Formula = $KClO_3$			
Element	K	Cl	O_3
Atomic Weight	39.1	35.46	16
Total Wt. of Element	39.1	35.46	48
Mol. Wt. of Compound	39.1 + 35.46 + 48	=	122.56
% of Element	$\frac{39.1}{122.56}$ · 31.9%	%	%

Per Cent of $\underline{K}$ in $\underline{K}ClO_3 = \frac{39.1}{122.56}$ of 100%

or 31.9%

but his work is usually so messy that no one but himself can understand it. To overcome some of these difficulties I have used the type of solution here illustrated with excellent results. It is not desirable that teachers adhere to this form very rigidly but rather adapt it to teaching situations of this type and in cases where other types of solutions have not given desirable results. Some of the simple details are not given in the illustration because they are self-evident to the teacher.

POSSIBILITIES IN ELEMENTARY SCIENCE

The possibilities in elementary school science are endless. They call for ability on the part of the teacher to recognize in the curriculum and in the environment both inside and outside of school, the experiences which involve science principles.—Helen K. Mackintosh in *School Life*.

THE SOLUTION OF PROBLEMS BY MEANS OF GRAPHS

LAURA BLANK
Hughes High School, Cincinnati, Ohio

One's approach, with a class, to the study of graphs is by way of pictographs, then bar graphs, disc or circle graphs, depicting parts of the whole, or distributions, then finally curved line and broken line graphs. Pupils gradually learn to read and interpret such statistical and scientific graphs. They are then taught to build the simpler ones, learning to realize something of the concepts of variability and functionality. They understand, by degrees, the advantage of the graphic method of presentation over a mere exhibit of a given set of related data, a graph as compared with statistically related numbers.

Later they study, under our guidance, one statistical or scientific graph superimposed upon another related graph, or perhaps several such, and the advantage of such superposition. Throughout the study, which together with the pursuit of other purely algebraic or arithmetic subject matter, might be carried on for a week or so, is the constant discussion of the graph as superior in certain respects to the set of related statistics from which it is derived, and why.

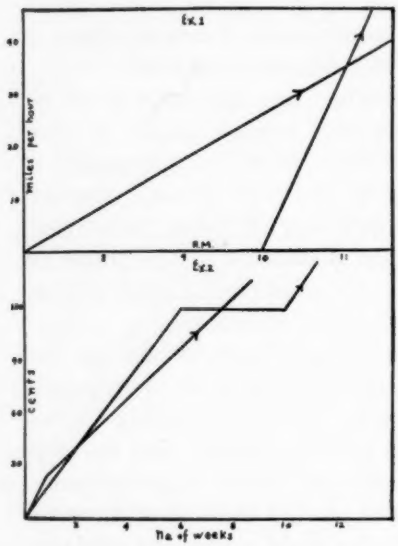
Now after this gradual growth we are about to take up the graphical interpretation of the formula, building up appropriate and related pairs of values, working out scales fitting to the formula, and number pairs, then plot the points and develop the curve. Possibly we have not yet considered negative numbers, or if we have, we have not yet plotted them. Nor have we gone over to the graph of the linear system, equations containing, as we say, "two unknowns," so abstract at first, to the novice.

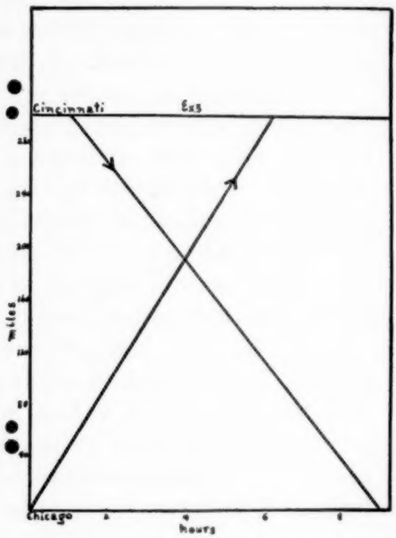
But wait. Just before plotting a formula, negative numbers, or a system of two linear simultaneous equations, the psychological moment has arrived to solve a few worded problems graphically. It is true, such problems as one would plot, can be solved arithmetically, by algebraic equation or by trial and error, perhaps more quickly than by means of a graph. Our reason for developing a graphic solution is that our method is an avenue of approach to the study of the formula and the linear system. Then our especial motive is the usual one in the study of graphs to present a vivid, quick appeal, expressing very evi-

dent relationships. We mean to tell the layman a "short short-story." He may not be much versed in algebra. Few folk are interested in statistics, related pairs of numbers, as such.

There are not many sorts of worded problems that can be solved graphically, but one can find or formulate a number of them, and those certainly not foreign to the youth's life today. Let us consider the problem:

A boy set out from home at 7 A.M. riding on his bicycle, averaging $8\frac{1}{2}$ mi. an hour. At 10 A.M. his parents started on an automobile trip. They averaged 34 mi. an hr. traveling the same road. How far away from home and how soon would they overtake their son? Solve graphically.





We find that the straight lines representing the respective distances intersect to show a distance of 34 miles at 11 A.M.

You prefer to solve it experimentally? Verify it so. Or solve it by equation: $8.5t=34(t-3)$. Is there a better way to show mathematical correlation? Infallibility of methods, all three?

What are we seeking in education, which is not strictly professional? All around education, appreciation, development. One makes his first trip to Norris Dam, let us say. What challenging thought is aroused? Thinking in terms of geography, geology, aspects of engineering, architecture, finance, economics and sociology; perhaps transportation.

Should we not, as educators, develop many aspects of a unit or topic, rather than just the easy quick way of making a hurdle? Moreover we are building for deeper and wider understanding ahead.

A second type of problem could be:

A boy deposits $.20 a week in the school savings bank for six weeks. He is unable to make another deposit for four weeks. Then he resumes his deposits regularly. His sister invests $.25 the first week. After that her deposit is regularly $.15 weekly. When were their balances identical, and how much were they?

The graph here is of interest because of the fact that the slope is not constant in either case. What characteristic of the broken line indicates steadiness of thrift? Instability?

For a third example, consider:

Two automobile parties set out, one from Chicago at 45 mi. an hour, and the other from Cincinnati, at 40 miles an hour. The latter was delayed one hour in starting They traveled the same road. Assuming a distance of 300 miles between the cities, how far out of Cincinnati, did they meet?

It makes an interesting graph.

Let us go back now to Ex. 1 thinking of it in terms of an independent and a dependent variable. We have the linear system: $\begin{cases} d=8.5t \\ d=34(t-3), \end{cases}$ simultaneous equations, and not of the easiest sort to plot, surely, in two unknowns, d and t. Pupils should be ready now to work on the graph of such an abstract example as $\begin{cases} x+3y=5 \\ 2x-y=3. \end{cases}$ The approach should be less blind, much more direct, and more meaningful than without this study parenthesis.

IRON METEORITE FROM AUSTRALIA

A ton of iron that fell out of the sky and plunged into the earth in Australia 36 years ago will be placed on display here soon, at the U. S. National Museum. It is probably a part of the great Cranbourne meteorite, for it was found in the same general region where other pieces of that body fell.

The largest fragment of the Cranbourne meteorite, which burst high in air as it was falling, is now in the British Museum in London. It weighs more than three tons. The second largest fragment, weighing about half that much, is now in the Melbourne Museum in Australia.

A PROGRAM FOR CONSERVATION EDUCATION IN THE JUNIOR HIGH SCHOOLS

B. J. Rohan
Superintendent of Schools, Appleton, Wisconsin

Guy Barlow
Principal, Wilson Jr. High School, Appleton, Wisconsin

Introduction

The preservation and continued enjoyment of Nature's bountiful gifts to mankind should be society's aim today if we are to permit our children to become the protectors of their own birthright of natural resources. Nature meant that we should use and enjoy our share of her wealth, but she did not intend that we should consume it. Basic economic and sociological planning presupposes that while we may use bountifully of Nature's gifts, yet we must return, insofar as is possible, the *principle* plus a little more for interest. In order, therefore, that our children may obtain a right to the heritage which is theirs, it is necessary that society possess the proper attitudes toward this scientific, social, and economic problem.

Ultimate goals in conserving our natural resources will depend upon a well informed and aroused public opinion. It is primarily a matter of education, an important phase of which consists in preparing both the present and future generations for their responsibilities in wisely using, as well as increasing, our natural resources.

Many schools have already recognized this need by adding conservation studies to their curriculum or by correlating and integrating this material with various subjects. Wisconsin in 1935 was the first state to make the teaching of conservation mandatory. It is encouraging to note that in other states conservation is being introduced in many school systems with or without the enactment of such legislation.

Educators today are definitely concerning themselves with the problem of building into their school programs adequate areas of conservation subject matter which may aid in planting proper ideals, attitudes, and concepts in the minds of their students. While an unlimited abundance of literature has been written on this subject much of it is not suitable or adaptable for pupil or teacher use. There is equally a widespread lack of knowledge as to how this subject may best be approached. The

objective of this paper is to provide at least a partial answer to this question.

In building a program of conservation education at the levels of the elementary, junior, and senior high schools, our teachers felt the need for certain basic guiding principles which would aid them in preparing a system of *teaching helps*. Questions were raised, and in the answers were found the philosophy and guiding principles upon which to base their procedure.

Before describing how the three conservation manuals were prepared let us first see what questions were raised, and what answers were found in the preliminary work as the conservation committee got under way. The five questions follow.

I. What Is Conservation?

Like the word "service," conservation has many meanings. In order to set a working basis for our purpose, its meaning shall be limited to the following definition. *Conservation is a means whereby society may use, yet at the same time perpetuate, its great natural resources such as forests, soil, water, plants, animals, birds, and minerals.*

II. Is There a Need for Teaching Conservation?

Society is built upon a foundation of natural resources. Man cannot live without water; soil is necessary to grow his food and clothing; plants and minerals constitute the raw materials upon which his industries are built. Early Americans looked to the natural resources of this country for the means of making a living. Lakes, rivers, forests, and soil offered the opportunity to provide food, clothing, and shelter for themselves and their families. A great nation was built upon the resources of this country. But time and continuous use has greatly reduced the quantities of our natural resources. By this reduction of natural resources millions of people have been removed far from the sources of these supplies—yet dependence upon these products of nature as a means of making a living is still of vital concern to mankind. It matters little if one is president of a university, a teacher in a public or private school, a clerk in a store, a farmer, the owner of a bank, or a politician; he must have food, clothing, and shelter. The abundance or scarcity of these materials affects every man, woman, and child. One may be selling life insurance or practicing medicine and apparently be far removed from the necessity of being concerned over the

source of raw materials, yet if for lack of them the industries of his city fail or move elsewhere, the outlet for what he is selling is much reduced if not completely removed. This condition is true for the vast majority of us. It makes little difference what our occupations are; we are dependent for food, clothing, and shelter upon an abundant supply of natural resources. Is there a need for teaching conservation? The evidence seems to say that we need to teach conservation so that each one of us may have the privilege of earning a living.

III. What Conservation Should Be Taught?

In general, an overview or panoramic picture of the whole field should be built. In order to do this enough educational activity should be carried on to establish in the pupil's mind, by the time he has finished high school, an understanding of the importance of an abundant supply of soil, water, minerals, plants, and animals. This is necessary because conservation of our natural resources is not only a scientific problem but a social and economic one as well. Through these means each segment of society will become conversant with the problem. This is of primary importance because the ramifications of conservation problems are so broad and inclusive that an adequate solution of them can only be had through the good will of the public. Thus the necessity of an overview.

Included in this primary aim of establishing a panoramic view of the whole field is the *specific aim of arousing interest in conservation*. This may be done through the use of materials and problems which are at hand. To illustrate: an informal study of the nests, colors, foods, and habits of birds in nature study in the elementary grades may well lead to a study of their economic value in the science classes of junior and senior high schools. We need the help of the birds in order to keep the balance in nature. Much money, time, and energy are spent today in an effort to cure ills of a struggling social world. Yet, while we are devoting our time and energy to fighting with one another individually and in groups, another struggle is in the making.

This struggle will require the united strength of mankind. It is a contest between insects and man for the control of the world. Insects haunt almost every sphere of man's activity. They are on the increase—the grasshopper plague illustrates the point. You are well aware of the often repeated statement

that the total weight of insects in the world is greater than the total weight of all animal and human life. Birds are man's best friend in fighting this common enemy. They eat tons of insects every day. A study of birds, therefore, can be made a very important and vital subject.

Again, the loss of soil through erosion is a problem in many farming districts. China once had plenty of fertile soil, yet through erosion she has lost much of it. Today her food supply is a problem. Famine, flood, and pestilence are her lot. We in American should profit by her loss. Every classroom can help in this problem.

Even a pot of flowers in a schoolroom offers a specific conservation lesson. The flowers are an emblem of the promise of abundance which God has given us. If we use, yet conserve, that abundance, the emblem will remain. These flowers are a reminder of that which we must lose if we do not awaken to conservation action. What conservation should be taught? We teach by using the problems and materials at hand and through their use build towards the necessary overview.

IV. Who Should Teach Conservation?

A notion which prevails at the present time is that whatever conservation is taught should be confined to agriculture or biology. This idea is similar to the old idea regarding guidance which held that one individual employed as a guidance director could do the guidance work of the school. Fortunately, this idea has been replaced by one which is much more sound; i.e., guidance, to be effective, must be a part of every teacher's work; guidance, to be effective, demands that every subject be explored for its guidance possibilities. The same is true for conservation. Every subject must be explored for its conservation possibilities. If conservation teaching is to be effective and if it is going to help solve this perplexing social, economic, and scientific problem, it must, like guidance, become a part of every teacher's work. While the amount of conservation taught will vary with the subject, yet every teacher should be a teacher of conservation.

V. Where Should Conservation Be Taught?

Since conservation has a social and economic as well as a scientific aspect, it cannot be confined to one course or one subject. Its ramifications are too many and too varied. However,

this should not disturb or distress us because a survey of any classroom will make clear that without one being aware of it much good material is already available in our present texts and supplementary literature. Any school or school system needs only to make a careful analysis of the teaching materials on hand to discover an abundance of conservation subject matter. All that is needed is some reorganization or some means of focalizing the material at hand in order to make it serve the purpose. Nature study, literature, geography, history, science, and even mathematics and art are all waiting and ready to be of help.

Where then should conservation be taught? It should be taught in all schools wherever and whenever a subject lends itself to such teaching.

As has been previously stated these questions were occupying the minds of our teachers' committee when they first were confronted with the task of building conservation into our school curriculum. It is also true that the answers here stated did not occur to them momentarily. It took considerable time and thought, hours of work, and many conferences before the deck was cleared for concerted action. Even then it was not until after they had made a thorough search for materials bearing on the subject of conservation in each grade and in each subject taught that they were convinced that a correlated and integrated program could be carried out. Finally, the answers to the questions which were raised at the beginning became the *guide posts* of the procedure eventually used.

The Procedure Followed in Preparing Conservation Manuals

A group of teachers known as the conservation committee were selected from the elementary, junior, and senior high school teaching staff. Each division was to be responsible for preparing the work at its own level. The elementary manual appeared first, followed by the junior and senior high school booklets a year later. Appleton's teaching staff is particularly indebted to the efforts of the personnel of the Wisconsin Conservation Department for the constructive criticism and personal assistance rendered them during the process of compiling these manuals.

The plan for constructing the elementary and junior high school manuals was to prepare an outline which might cover

every phase of natural conservation. The second step was to devise a method whereby any conservation material found in the content of both grade and junior high school courses could be tied into this outline. This was followed with the development of general and specific objectives for each phase of the outline. A tabulation of text and supplementary materials, as well as a list of activities which would help meet the general and specific objectives was the next step. The general outline used was as follows:

I. Animal Life
1. Wild Life
2. Game Birds
3. Fish
4. Insects
5. Birds

II. Plant Life
1. Plants
2. Wild Flowers and Ferns
3. Weeds
4. Landscaping—Yard and Lawn
5. Forests

III. The Earth's Surface
1. Soil
2. Grass
3. Water (Power, Lakes, Rivers)
4. Irrigation
5. Dam Projects
6. National and State Parks
7. Minerals

I. How Did Teachers Help in Discovering Conservation Materials at Hand?

A mimeographed form which provided a space for listing such items as objectives, sources of content material (having a bearing on the general conservation outline), activities, and supplementary material was given to each teacher. With the form as a guide, teachers sought out and listed materials in their field which had a direct bearing on the conservation outline. The idea of integrating or correlating conservation with all subjects was constantly kept in mind. A surprising amount of material was discovered. All that was needed, therefore, was some means of organization to focalize and make it serve the purpose.

II. How Are the Elementary and Junior High School Manuals Used in Teaching Conservation?

Grade and junior high school teachers were given copies of the manuals written for their departments. These booklets provide an easy means for the teacher in discovering what materials in her field have a direct bearing on the general outline

of natural conservation. How does she make use of her conservation manual? Let us take for example a teacher of 7th grade English in the junior high school. The table of contents refers to pages in the manual upon which are listed references to class work material. These references in turn list titles, authors, and pages whose subject matter ties in with the general outline.

Using these references, the teacher opens a desk copy of the texts she is using, to the pages listed. At the beginning of each article or unit she writes the word CONSERVATION in the margin of the page of her desk copy. This is her KEY which indicates that various implications of conservation activities may be correlated with this unit.

If these references have been properly "keyed" by all teachers in all subjects and for all materials taught in the school system, one can readily see the effectiveness of such an integrated conservation program.

III. How Was the Senior High School Work in Conservation Developed?

At the senior high school level the natural sciences such as biology, chemistry, and physics by the nature of their respective subject matter offer considerable opportunity to deal with various aspects of natural conservation. Because conservation of our natural resources is tied up so closely with life, it provides a fundamental social problem to be emphasized in the social science courses. Even in the subject of art as taught in the senior high school certain aspects of conservation can be treated through the use of nature posters and designs. Such was the discovery after members of the committee had met to plan a procedure for the teaching of natural conservation at the senior high school level.

The manual which was finally devised first presents statements of general principles and objectives. These are followed by unit outlines from courses in social science, biology, chemistry, physics, and art in the order named. The style and organization of materials in this booklet varies from both the elementary and junior high school manuals. The ends sought, however, are about the same at all three levels. At present all teachers in our system, regardless of what grades they are teaching, emphasize various phases of conservation as the opportunity naturally arises. The final result is a united teaching effort

concentrated upon this subject while in the past it consisted of periodic punches by only a few.

IV. In What Practical Phases of Conservation Work Have Appleton Pupils Participated?

Some one has made the statement that "habits of action are not formed by discussion, but by participation." We can teach boys and girls in the classroom the proper ideals, attitudes, and concepts toward conservation in general, but the lessons taught make deeper impressions when supplemented by a program of action. That program does not necessarily mean the transporting of boys by trucks to reforest great areas of cut over land. Many of us live in towns and cities too remote from that territory.

In Russell Conwell's story *Acres of Diamonds* he found the diamonds in his own back yard. We whose business it is to educate can find ample opportunity for an active conservation program in the communities in which we teach, on the school grounds where we work, and adjoining our homes in which we live.

For example, Our Hobby Club activity program held once each week (during school time) is one of the finest ways of putting to work the excess energy pent up in pupils of junior high school age as well as to enrich the school program by exploring greater fields. Activity in conservation in Appleton has an outlet through the Junior Izaak Walton Club. A word picture of the program carried on in this club by individuals and by groups would be so lengthy that many of the details would have to be omitted. Appleton is fortunate in owning a motion picture of junior high school conservation activities. From this motion picture *Defenders of Outdoor America* we hope you may receive ideas interesting enough to be duplicated in your own communities.

"TUG BOAT" FOR PLANES

Like a tiny tug boat pulling a giant ocean liner is the new "iron mule" recently developed by Wright Field Air Corps Engineers, and now seen in action on the flying line as it tows giant bombers from the field to shops and hangars.

Said to be twice as powerful as other towing vehicles previously designed, the new tractor is especially designed for towing giant aircraft like the B-15 super flying fortress, and still larger projected planes of the future. It weighs approximately 6,000 pounds, is nine feet long, and develops a drawbar pull of more than 4,800 pounds. Operated with conventional automotive controls, it starts very gently so that there is no jar to the airplane in tow. At low speed its movement is barely perceptible. Its top speed is about 15 miles an hour. It is capable of turning within a circle with a radius of little more than ten feet.

LABORATORY PLANNING AND EQUIPMENT

William Albert Earl Wright
State Teachers College, Shippensburg, Pennsylvania

[It is hoped that this article will prove of interest, not only to those chemistry teachers who are so fortunate as to be about to have the privilege of helping to design their own new laboratories but also to many others who want to keep informed in regard to recent advances in the matter of materials and construction. In the case of teachers who are actively engaged in planning laboratories it is urged that they get in touch with their architects very early in the course of the planning so that they may not be handicapped by previous determination of structural members. For those who are not acquainted with it the splendid volume on *Laboratory Construction and Equipment* gotten out in 1930 by the National Research Council and published by The Chemical Foundation is highly recommended. F. B. Wade.]

Introduction

The layman regards the method used in the furnishing of a laboratory in the same category as that used in the furnishing of a house. However, the experienced science instructor realizes that fitting the furnishings to the laboratory is not the correct method. Instead, the laboratory should be so designed that it will accommodate the desired furnishings and equipment.

To accomplish this objective, the science instructor must furnish the architect with full and exact details concerning the furnishings and equipment desired so that he may design the laboratory in harmony with, and to include, expedient features. Therefore, careful and judicious planning forms the background for the information furnished to the architect. In return, the architect should seek and recognize reasonable requests of the science instructor concerning specific service requirements. Upon ascertaining that, for proper and substantial reasons, a service requirement must be omitted, the architect should seek a conference with all interested individuals instead of arbitrarily omitting the item from the plans without full explanation.

Sources of Information

The sources of information which may be used by a science instructor confronted with the problem of laboratory planning and furnishing are: recent literature, visits to recent laboratory installations, consultations with technical experts of equipment companies, and equipment catalogues.

Floor Plan Layouts

Careful attention must be given to "spot" plans which show equipment conveniently and economically placed. The "spot" plans will include accurate location of all piping required for drainage, hot and cold water, gas, steam, vacuum, distilled water, compressed air, hydrogen sulphide, mechanical ventilation, and a combined control, charging, and distribution panel furnishing A.C. and D.C. current of various voltages and to include wiring to motor generator and battery and to students' and instructors' tables. A properly planned laboratory permits many economies in equipment to be effected.

Compilation of Connection Check Lists

The most effective method for preventing connections from being omitted requires the compilation, by the science instructor, of a separate check list of desired connections associated with each item of furniture or equipment.

The following may be used as examples:

1. Chemistry tables:—144″×54″, drain trough, end sink, A.C. conduit, D.C. conduit, gas, hot and cold water, steam, Duriron waste pipes, Durimet downdraft mechanical ventilation ducts.
2. Barnstead Still:—Cold water, waste, and an A.C. line capable of carrying the required current connected through a heavy duty switch directly to the main power line.

If this procedure is pursued with each separate item and finally checked with the location of all piping on the completed "spot" plans, serious errors and omissions will be prevented from occurring.

Types of Laboratory Furniture

No attempt will be made to discuss the various types of different items of laboratory furniture, since the selections will be dependent upon local factors and conditions such as cost, size of laboratory, and specific service requirements of the instructors concerned.

In the opinion of the writer, the most important factor to be kept in mind is that "cheap" furnishings may prove to be quite expensive over the period of years the furniture is in use.

Criteria for us in selecting the equipment company to supply the furnishings are: Integrity of the company; experience in the manufacture of laboratory furniture; success of their recent installations; maintenance of a long experienced and highly

trained engineering department for the purpose of insuring satisfactory installations, constant improvements of designs, materials of construction, or construction methods; and finally the ability to completely manufacture (except accessories) all items of furnishings in their own plant, especially the mechanical portions of the work.

Wood Versus Metal Furniture

There is considerable difference of opinion as to the most suitable materials from which laboratory furniture should be constructed. At the present time, wood and lead coated enameled steel are used exclusively in the manufacture of metal case work and cabinet work of all laboratory furniture with the exception of fume hoods.

The problem of corrosion of metal furniture, by fumes of highly concentrated chemicals, must be considered by the purchaser. However, when the writer contacted twenty-one purchasers of metal furniture only four expressed minor dissatisfaction. If corrosion occurs, it will probably be found around the hoods and other places where there is direct contact with large quantities of corrosive fumes. Metal case work and cabinet work of laboratory tables are usually not subject to corrosion since they are not in contact with large quantities of corrosive fumes. At this point, it must be stated that the problem of probable corrosion exists only as far as the chemical laboratory is concerned. The problem of corrosion of metal furniture does not exist in the biology or physics laboratories.

Specially developed synthetic resin enamels and oil varnishes are used for finishing the metal. Several coats are applied, each coat being individually baked in high temperature ovens producing an extremely hard plastic finish that is very resistant to acids, alkalies, and solvents. In event of accidental damage to the metal finish, it is possible to repair or replace with fast setting air dry enamels to match the original finish. Mechanical damage to the finish on metal laboratory furniture can only be accomplished by a severe blow with a sharp instrument.

If appearance, sanitation, and absence of mechanical difficulty are factors in the selection of materials, metal furniture will be more satisfactory than wood furniture.

Metal furniture is not subject to appreciable expansion or contraction and is absolutely free from warpage. Fastening of the different parts is accomplished by various electric and acety-

lene welding processes thereby permanently fusing the joining members together. Modern methods of cold forming light gauge metal into structural shapes make possible extreme rigidity and strength with corresponding light weight.

The operation of drawers and doors of wood equipment is somewhat more quiet than metal equipment. However, most experienced instructors have encountered expansion and warpage in wood equipment which causes drawers and doors to "stick."

Supporting members of large cross section must be used to obtain structural strength and rigidity in wood equipment. Fastening of the various parts of an integral wood cabinet unit are dependent upon glue joints, dowel pins, or bolts. Modern wood cabinet construction obtains very great glueing surfaces by means of mortise and tenon and dovetail joints. Modern glues, used in wood cabinet construction, are very resistant to moisture and general disintegration. The breakdown of a glued joint is usually attributable to expansion and contraction of the wood members brought about by atmospheric conditions.

Which material is the more satisfactory for general use? This question must be answered by individual preference. The individual scheduled to use the furniture must decide whether expansion, contraction, and warpage of wood furniture or possible corrosive action of fumes on metal furniture is the more objectionable feature. One leading manufacturer of both wood and metal furniture reports that, during the past year, the sales of metal furniture have been running slightly ahead of the sales of wood furniture.

Materials of Construction

1. *Steel.*—Sheet metal used in the construction of laboratory furniture should be a copper-bearing steel alloy. In addition, the sheet metal should be coated with hot lead on both sides and finished with an enamel highly resistant to acids, alkalies, and solvents. Special emphasis should be placed upon the necessity of insistence upon the sheared edges of sheet steel being coated with hot lead after shearing and notching. Steel tubing used for legs on tables should be coated with hot lead inside and outside.

2. *Wood.*—Oak used for exterior construction as well as the birch and maple used for interior construction should be thoroughly air-dried for twelve to eighteen months. Then the wood should be kiln-dried until the moisture content has been reduced to $4\frac{1}{2}$ per cent.

Several manufacturers are marketing laboratory furniture constructed from plywoods glued with thoroughly waterproof glues which they claim eliminate expansion and contraction inherent in standard wood laboratory furniture.

3. *Table Tops.*—Wood tops, even though finished to resist acids, alkalies, and solvents, are not impervious to the above mentioned substances. Likewise wood tops char when a lighted burner is overturned or when too much heat from a flame is reflected upon the table top. Exacting care is required to keep a wood top in good condition.

Soapstone is practically impervious to liquids and is not readily attacked by acids and alkalies. Although soapstone is fireproof, it may crack when subjected to severe heat covering a small area. Soapstone is regarded as somewhat undesirable since the surface becomes scratched and pitted. Application of protective coatings and resurfacing adds to the cost of maintenance.

Pitch-impregnated asbestos has not been well recommended by purchasers contacted due to its inability to stand up under the action of heat or solvents. Using appearance, cleanliness, transverse strength, resistance to scratching and abrasion, impact strength, imperviousness to liquids, resistance to stain or solvent action of organic liquids, resistance to heat and thermal shock, noncombustibility, and resistance to stain and corrosion by acids and alkalies as criteria, Phelps and Marbaker[1] report that vitrified CERAMIC ware tops (Kemite) conform closely to the criteria. Ceramic ware tops are practically non-absorbent, free from internal weakness, offer high resistance to thermal shock, are easily polished, and are exceptionally easy to keep clean. Phelps and Marbaker[2] further report that, with the exception of Hydrofluoric Acid, mineral acids have no appreciable effect on Kemite. Superficial etching, without affecting the original smoothness, is caused by concentrated solutions of alkalies. Kemite should prove to be one of the most popular and efficient tops ever developed for chemical, physical, or biological tables.

4. *Sinks.*—Sinks may be manufactured from soapstone or a vitrified ceramic material called Karcite. With the exception of a difference in the coefficient of expansion, the properties of

[1] Phelps, Stuart M. and Marbaker, Edward E. "New Ceramic Table Tops," *Industrial and Engineering Chemistry*, XXIX, May, 1937, pp. 541–547.

[2] *Ibid*

Karcite are very similar to Kemite. Karcite sinks are easily polished and exceptionally easy to keep clean.

5. *Waste Lines.*—Probably the most important material used for waste lines at the present time is Tellurium lead. This material is resistant to many concentrated and most dilute corrosive materials. Its advantages are low material and installation cost, ease of replacement, and great flexibility. However, certain corrosive materials cause deterioration and large quantities of mercury are destructive to lead waste lines. Flexibility of Tellurium lead lines permits bends at the time of installation to avoid pilasters, pipes, or conduits without using fittings. This property is particularly advantageous when installations are made in remodelled or old buildings. Since lead waste lines are non-rigid and flexible they are not affected by vibration or settling of a building.

High silicon iron waste lines are next in importance. Permanence, non-leakage through absorption, and resistance to corrosion are the advantages of this material. High cost of material and installation and possibility of leakage through joints caused by vibration or settling of a building, unless the pipe is supported at frequent intervals, are its disadvantages.

Chemical stoneware offers great resistance to corrosive materials. Its disadvantages are high cost of material and installation, inflexibility, and tendency to leak through absorption on horizontal runs where lines remain wet and some pressure may be developed. The manufacturers claim that a newly developed cemented rubber joint is permanent and affords some flexibility in the lines. Settling of a building or building vibration may cause leakage through joints. Pipes manufactured from this material must be supported at frequent intervals.

6. *Exhaust Ducts.*—The majority of duct installations are of lead coated copper bearing steel. It is inexpensive, light in weight and more or less self-supporting. The ducts are painted on the inside with asphaltum. However, corrosive fumes or condensate may attack the ducts made from this material.

Durimet, an excellent material for duct construction, is light in weight, easy to install and offers great resistance to corrosion. Durimet may be classified as a permanent material for duct work under practically all conditions. However, duriment is a very costly material.

7. *Wall Fume Hoods.*—The installation of the correct type and size of fume hood is an item of major consideration in order

to insure removal of poisonous and obnoxious fumes from the laboratory. The type of baffle construction selected will depend entirely upon conditions of use and the desires of the individual instructor.

Fume hoods constructed from soapstone are highly resistant to fumes. However, the great weight and bulk of the soapstone hood is disadvantageous.

Fume hoods constructed from chemical impregnated asbestos material have been recommended by certain manufacturers principally because of the fact that hoods constructed from this material are lighter in weight. Aesthetically minded instructors would probably prefer chemical resistant impregnated asbestos material framed with metal which has been coated on both sides with hot lead and finished with an enamel highly resistant to acids, alkalies, and solvents. Metal framed impregnated asbestos hoods afford structural strength with light weight and permits easy moving and re-locating at any time desired.

Kemite offers great possibilities for hood construction as soon as manufacturing difficulties are overcome and it is possible to produce slabs of sufficient size to be practical for hood construction. A hood constructed of Kemite and framed with metal which has been coated on both sides with hot lead and finished with an enamel highly resistant to acids, alkalies, and solvents should prove to be light in weight, and present a pleasing appearance in addition to its non-corrosive properties.

Wood fume hoods are obsolete and are not recommended by leading manufacturers. Wood fume hoods may be secured if desired. Warpage and expansion is encountered to some extent. It is more difficult to keep wood fume hoods in good condition than fume hoods constructed from certain other materials.

Regardless of the material selected for construction of the superstructure, safety glass should be specified for the sashes and hood ends.

Recent reports show that 2,500,000 children of elementary-school age in the United States are not in school and that 2,500,000 are in schools that are little better than none.

A child cannot rise above the country in which he lives. The power of self-government to survive and the success of the individual citizen alike depend upon the wise education of all the people.

TRENDS IN SUBJECT MATTER ORGANIZATION IN HIGH SCHOOL CHEMISTRY*

M. Curtis Howd
Hononegah Community High School, Rockton, Illinois

The organization of a course of study deals not with the content, but rather with the methods of approach, the purpose, and with the devices which are used to achieve the aims of the course. It is along these lines that I shall attempt to discuss the present trends in the organization of the subject matter in the high school chemistry course.

The need for a reorganization of high school chemistry has been brought about by the changes in social and economic conditions which have taken place in this country during the past ten years. These changes have produced an increased enrollment in our high schools of students whose formal education will stop upon graduation. Fewer of the graduates, therefore, will go on to college, and hence, most pupils will have no need for the college preparatory type of course which has been commonly used in high school chemistry. According to the statistics given in the United States Department of Interior *Bulletin Number 2*, published in 1933, out of each one hundred students who graduate from high school, thirty-five will enter college. Of these thirty-five less than ten will indicate as freshmen a desire to specialize in those fields where there is a need for chemistry, and of these two will graduate in one of these fields. Thus, ninety-eight per cent of the high school graduates will become non-scientific citizens in a world which is being rapidly changed by science.

The reorganization of our courses has been slow. This may be due in part to the dominating influences of the college entrance examination boards and to the fact that textbooks written prior to the realization of these new needs still serve as the basis for the organization of our chemistry courses.

To meet these new demands upon high school education the Committee on Chemical Education of the American Chemical Society recommends in "An Outline of the Essentials for a Year of High School Chemistry"[1] that in the high school the view-

* Prepared for the Chemistry Section of the Illinois State High School Conference, November 4, 1938.

[1] Hopkins, Mattern, Segerblom, Gordon, "Report of the Committee on Correlation of High School with College Chemistry," *Journal of Chemical Education*, Vol. 13, pp. 175–179, 1936.

point should be informational, broadening, and cultural as contrasted with the technical, professional, and specialization attitude which is unavoidable in the college; namely, to plan the course to meet the needs and interests of the pupil. It lists among the aims: (1) to show the service of chemistry to the country, (2) to develop this service around certain minimum fundamental topics, (3) to train the students in keen observation, exact reasoning, and in the scientific attitude of mind. I have found in my reading and research upon this topic that the present trends seem to be centered about these recommendations.

The first of these points is that the high school viewpoint should be informational, broadening, and cultural. This is in accordance with the tendency to humanize chemistry and to produce a course of study around the social needs of the students. Such a course is often called cultural chemistry. Professor Hopkins has very ably described the goals of this type of a course thus: "A cultural course must, then, develop not merely an appetite for intellectual attainment and moral excellence but it must contribute definitely toward open mindedness, sincerity, an active interest in social betterment, and a productive participation in all enterprises which have as their ultimate goal the uplift of humanity. . . . It must humanize his character and intellect. . . . The deciding factors are determined by the method of approach, the purpose for which the subject is studied and the general attitudes of mind carried away by the students themselves."[2]

As is implied, the starting point of such a course is to be found in the environment of the students. The teacher of this course will have to study the economic, industrial, and social factors in the environment to find those ways by which he can enrich the lives of his pupils through the medium of the subject matter in chemistry. It is not difficult to find a relationship between chemistry and life situations. Many problems, from the farmer's to the doctor's, are chemical in nature. In essence the problems of the individual, the business man, and the community are chemical problems. Among these are the relationship of chemistry to disease as is shown by a study of antiseptics and disinfectants; contributions of chemistry to transportation such as the alloys which have made modern trains and airliners pos-

[2] Hopkins, B. S., "The Cultural Value of Chemistry in General Education," *Journal of Chemical Education*, Vol. 12, pp. 418–422, 1935.

sible; the production of safety glass; the development of polaroid glass being used in the new Union Pacific trains; and contributions of chemistry to safety education such as a study of carbon monoxide poisoning. Through a study of the relationship of chemistry to these problems found in current life an attempt is made to show the economic effect or the social effect which they have produced.

In some of the newer textbooks there is an attempt being made to bring out these relationships of chemistry to life. In one text, copyrighted 1938, the author states in the preface that: "It is primarily for the purpose of pointing out some of the remarkable ways in which modern chemistry affects life that this book is written." In this text some of the topics are: Chemistry and Health, How Chemistry Helps the Doctor, Protecting and Cleaning Surfaces, Chemistry of Cooking, Chemistry in Relation to Agriculture, A Chemist's Relation to Canned Foods, Chemistry and Warfare, and Chemistry as a Life Work.

The relationship of chemistry to the life processes, to the home, the community, and the country is being emphasized in the organization of the high school chemistry course. Thus oxygen is not being studied for its own sake but is studied as a substance which is essential to life. By so relating the factual material in chemistry to the life of the student it is hoped that he will become a better member of society for having had this course.

This socialization of chemistry has led to a definite change in the organization of textbook material. The services of chemistry are being organized around minimum fundamental topics or units. Under the older topical method of organization there was little, if any, attempt to relate the different topics. The unit is organized so there is a definite relationship between that which precedes and that which follows insomuch as the subject matter will allow. By this arrangement it is hoped that the student will learn more effectively by having his attention concentrated for a time on a definite objective. It has been suggested that there be not more than fifteen of these units. The Committee on Education of the American Chemical Society have eleven units in their recommended course which is quite a contrast to the twenty-eight topics which this same organization suggested for the minimum requirements in 1924.

A study of these suggested eleven units will reveal several

important trends. In the introduction and at several places, such as in the unit on the periodic table, an opportunity is given to emphasize the historical development of chemistry. Here one has an opportunity to show how the scientific method actually works. A large army of scientists have placed their faith in the laws of nature, knowing that science brooks no falsehoods or deceptions, and through hard work involving many sacrifices, and in most cases repeated attempts, they have achieved their goal. Brief biographies of these men and extracts from their original writings will help to increase the human interest in our subject. This is one source of appeal to the student which has been neglected. In the new textbooks more space is devoted to brief biographies which we should be able to use very definitely, not only for their appealing interest but as a device for character building. Take, for example, the sacrifices which Madame Curie had to make to learn the truth. These ought to be the root of some noble aspirations in our students who are not very far removed from the hero-worship age. Character building is one of the most important tasks of a teacher and more emphasis is being given to its development.

A few significant chemical processes are studied in detail in order that the student may become acquainted with the industrial importance of chemistry. In conjunction with these studies special trips may be made to the various industries in the community which will give students an opportunity to see how a knowledge of the laws of chemistry is put into practical use. These trips can also serve another and probably more important function—that of guidance. It is guidance in that it acquaints the student with the working conditions of people and in particular of the chemist, the work that a chemist does, and, in general, with what is expected of the chemist. This should be followed by a study of what the chemist may expect in return. Through such studies a student will be given an opportunity to find whether or not he has a desire to take up chemistry as his life work.

Since it is impossible for all of us to visit enough industries to enable the student to become thoroughly acquainted with the common chemical processes, there is a trend toward the use of visual aids as a substitute for first hand knowledge. In many respects a moving picture or slides can better serve the purpose of acquainting the students with a chemical process than a visit to the industry itself, for when you visit a factory, you cannot

see inside the working apparatus. In going through an industrial plant where they are producing sulfuric acid by the lead chamber process you are told, "Here is the place where the stuff goes in. It goes up here, over there, and comes out down here." And what you see are big lead rectangular boxes from which a syrupy liquid is flowing and a big tower from which a reddish brown gas is escaping. In visiting an oil refinery one is lost in the maze of operations taking place, but in the motion picture of this same process by the use of animated diagrams you can see within the apparatus the actual processes taking place. The kinetic theory of matter has a more definite meaning to the students after they have seen the moving picture on "The Molecular Theory of Matter."

In the use of visual aids more emphasis is being placed upon the use of the microscope and microprojector. These two instruments are used very extensively in the commercial laboratories but have been used but very little in the high school. There is now a cheap microprojector on the market which is suitable for high school use. These instruments may be used to an advantage to show fibers, crystals in metals or alloys, or growth of crystals in a replacement experiment.

Many teachers are going still further in this work by making valuable use of the free literature and free displays which are provided by many of the larger industries and are encouraging their students to make chemical scrapbooks. The material for these books is to be secured from the current newspapers and periodicals. The securing of this material and properly presenting it to the class can serve as a good student project.

A definite attempt is being made in the organization of high school chemistry courses to make use of the more recent developments in psychology which have shown us that a person learns best who is actively and whole-heartedly engaged in some purposeful activity. Thus there is a tendency to provide for more pupil activity and less teacher activity. Some of the ways in which this is being done are through use of projects and the encouragement of hobbies among our students. Some of the associations which can be made between chemistry and hobbies are to be found in photography, growing plants with soil and without soil, making a mineral collection, and coin collecting. One can often teach a lot more chemistry through a hobby than through a textbook and can do far more toward developing personality. Those of us who attended the Curriculum Con-

ference at the University of Illinois this past summer had an opportunity to see how worth while projects have created a great deal of interest and enthusiasm for chemistry in the Normal Community High School. Some of these projects were the silvering of a mirror, making cosmetics, and tanning a rabbit skin which was finally made into a muff. The use of projects in a chemistry course stimulates interest; and after you have gained the interest of the student, it is not hard to sell him what you have to offer. The use of projects and the developing of hobbies is an attempt on our part to teach a worthy use of leisure time to our students. Though teachers as a group have little leisure time, it is a very real problem for the student. With the continued reduction of the working time of laborers it will become a greater problem to the student as a member of society. Here we have an opportunity to equip the student with an interest in doing things just for the pleasure that he gets out of the doing. There is always, too, an opportunity to turn a hobby into a vocation. Besides being a good teaching device, then, the project and the hobby serve another educational function—that of providing for use of leisure time.

Another theory of psychology which has found its way into our course of study is that people differ in the manner in which they learn and in the capacity to learn. In our courses a provision is being made for these individual differences in the form of optional exercises, additional problems for the superior students, and suggested activities. In these suggested activities greater emphasis is being given to the use of periodicals and newspapers in an attempt to tie the principles which are being studied to the current world affairs.

In following out this trend some attempts have been made to organize the course on the contract method. By this method the course is outlined in such a way that the material to be covered is graduated from a minimum to a maximum amount, and the student contracts to do an amount which is comparable to his ability.

Just how extensively the project method and the contract method is being used is difficult to say, but there is a definite trend in the organization of high school chemistry around greater pupil activity. The most effective learning is always the result of purposeful activity on the part of the learner.

Few of the bare facts of chemistry are retained by the average student after he takes his final examination. There is, therefore,

an increasing tendency to place emphasis upon the development of habits, attitudes, and appreciations through the study of chemistry. One of the habits which is receiving much emphasis is that of teaching the student to think for himself. This is shown by arranging the subject matter in the form of problems to be solved. In the solving of these problems the scientific method is used. Emphasis in every case is upon the meaning of the material which is presented to the student, for only as material has a meaning to the student will it be of use to him. To bring out these meanings necessitates the reorganization of the textbook materials so that they are relevant to the life of the student. This is quite different from having the student give back to you what he has memorized from the text. It is necessary to think in terms of chemistry and the environment if the student is to see a meaning in the factual material.

Besides encouraging the student to think, this method of procedure tends to develop the scientific attitude of mind. By this I mean the general point of view from which the scientist should approach problems, not only in his own field, but in his relation to life as a whole. This attitude should develop in the students a desire to discover the truth, the habit of basing judgment on facts rather than on opinions, the realization that all sources of material are not equally dependable, and a recognition of the universal relationship between cause and effect. Some ways by which attempts are made to get the students to think in terms of the principles of chemistry are to be found in the newer texts in the form of "questions of understanding" or "using facts and applying principles." Under this latter heading the facts might be given to the students by statements such as these: a bottle of ginger ale fizzes when opened; or, chemically pure water will not conduct electricity but natural waters will. If a student can use scientific principles to explain common facts of this type, then it should be reasonable to expect that he could use these same principles to explain other related facts which he will meet long after the chemistry course is over.

Since psychologists have proven by experimentation that "transfer of training" takes place only to the extent that there are identical elements of some sort in the different situations, it is then our job to make as many situations in our course identical to situations in our environment as possible. We must then, train our students to think their way through these situations. Some memory is necessary, but it is to be used only as a

means to an end, not an end in itself. There is a pronounced trend towards organizing a course of study to incorporate the "learning habit," the ability to think in terms of the data presented and the principles involved.

No discussion of the present trends in subject matter organization would be complete without some mention being made of the attempts to integrate the chemistry course with the other subjects in the high school curriculum. The most definite attempt in this respect has been to combine physics and chemistry into a physical science course for the senior high school. Although this trend is not very pronounced, it is present as evidenced by the appearance of a new book or two each year on physical science in the high school. A few of these courses have found their way into the larger high schools, but I believe that it is in the small high school where such a course will meet with the greater success. I have been interested in such a course for some time, and I think that a physical science course might best be adapted to meet the needs of the small high school where courses in both chemistry and physics are impossible because there are not enough students for the two classes or not enough funds to purchase equipment for teaching both. The science program which we are teaching should be made to fit the community in which we are living. If the needs of your community can best be served by a physical science course, then I think it should be introduced.

In summarizing the trends in subject matter organization, there seems to be a general broadening of the purposes of high school chemistry so as to give emphasis to its social significance by relating chemistry to current problems of everyday life. The facts of chemistry are subordinated to the development of character and personality.

The course tends to be organized into units—that is, into major ideas or concepts which are based upon general principles of science or upon life situations. In these units increased emphasis is given to the study of projects and to the solution of practical problems which tends to correlate the classroom recitation with life situations. Throughout all of the course greater emphasis is being given to visual aids and to the use of periodicals and current literature.

There is a general trend toward student activity because a student learns best by doing.

Allowance is being made for individual differences. Through

these activities the student is trained to think in terms of meanings of the scientific principles and to apply the scientific method to the solving of his problems. Only as material is made to have a definite meaning to the child which he can relate to his surroundings will there be any carry-over of his chemistry into his life activities. Life preparation is the goal toward which the reorganization of high school chemistry seems to point.

Science is a fascinating subject, and that it can be made interesting is evidenced by the fact that books based upon scientific subjects have been among the best sellers and that over one hundred newspapers subscribe to a syndicated science service. Chemistry in the high school will be both practical and appealing to the student if it is properly presented.

JUNIOR COLLEGE DIRECTORY

Greatest annual increase ever recorded in students attending junior colleges in the United States is revealed by statistics just compiled by Walter C. Eells, Executive Secretary of the American Association of Junior Colleges, for publication in the annual *Junior College Directory, 1939*.

The enrollment in this relatively new but highly significant group of institutions has increased from 1936–37 to 1937–38 from 136,000 to 155,000 students. This is an increase of 14 per cent for a single year. During the past decade the number of junior colleges has increased 36 per cent while the enrollment in them has almost tripled. In 1929 it was only 54,000.

The number of junior colleges now reported is 556. While many of the junior colleges are relatively small, there are 130 which have enrollments in excess of 300 students each, 29 which have enrollments of more than 1,000 students, and three which have passed the five-thousand mark. The junior college at Los Angeles is the largest of all with an enrollment this year just over 6,000. The three junior colleges which are part of the Chicago school system have an enrollment of over 5,300 students.

California leads with 57 such institutions and an enrollment of 53,000. Texas is next with 38 junior colleges, followed by Iowa with 37, Oklahoma with 32, Kansas with 24, Missouri with 23, North Carolina and Mississippi with 22 each, and Pennsylvania with 20.

"The junior college is not only furnishing the equivalent of the first half of a four-year college or university course to thousands of students who could not otherwise afford it," said Dr. Eells in commenting on these figures, "but even more important, it is furnishing a liberal education to additional thousands of young people who otherwise would not attend college at all and who cannot be absorbed by commerce and industry upon their graduation from high school. It is also giving many young people semi-professional courses which enable them, upon graduation, to become productive members of society."

"There is every reason to believe," Dr. Eells continued, "that the junior college enrollment of the country may double again in the next few years. California now has one junior college student for each 107 of its population. If the rest of the United States were equally well supplied the junior college enrollment would be 1,200,000 instead of only 155,000."

NEW MATERIALS AND EQUIPMENT IN THE TEACHING OF MATHEMATICS*

B. R. Ullsvik
Wisconsin High School, Madison, Wisconsin

I trust that all of you have received a copy of the bibliography entitled, "New Materials and Equipment in the Teaching of Mathematics." Mathematics is here defined as secondary school mathematics, and that which is new has a publication date not more than two years old. No pretense is made that this bibliography is exhaustive, but rather it is a sampling of the new materials and equipment that I had occasion to come in contact with.

Since the association devotes its energies primarily to secondary education, little space is given to arithmetic. Yet it does justify recognition, for secondary education must provide continuity with the elementary school. Some of the recent texts and publications are here listed for those secondary school teachers who wish to provide continuity with the recent developments in arithmetic.

The periodical publications are divided into three categories; administrative, philosophical, or research; curricular; and pedogogical. Such a categorization seems in accordance with the setting of mathematics as accepted by many recent writers. No longer is mathematics viewed apart from the other subjects in the curriculum, but rather a part of the curriculum. Thus the term "mathematics curriculum" has little meaning since the curriculum is viewed as inclusive—the fabric of education. Thus mathematics is interwoven in the fabric, acting and re-acting not only upon the individual pupil but also on other parts of the curriculum. With that conception the objectives of mathematics are the objectives of general education. Thus mathematics cannot justify its place in the secondary school curriculum by the unique contribution it can make to the development of the individual, but rather by the degree and character of emphasis that it contributes to the accepted general objectives of education. This emphasis may be unique, but yet it will have relationship to accepted general objectives and to the contributions of the other parts of the curriculum. These

* Address delivered before the Central Association of Science and Mathematics Teachers at Chicago, November 25, 1938.

periodical publications seem to give emphasis to this setting of mathematics which necessarily incorporates an integration of mathematics with other parts of the curriculum. A number of these references advocated an integration within the field of mathematics as a means of creating a conception of mathematics as a whole—as a science and the degree and character of emphasis that such a conception can foster.

Visual education has made much progress relative to mode of presentation and availability, but much is yet to be done before motion pictures can be used extensively in the mathematics classroom. First, the supply is very limited, and second the films are not readily available. In order to make mathematics meaningful to pupils, we must form a relationship between the new concepts presented and the pupil's previous experiences. That is to say: pupils learn that which is consistent with their previous experiences. Thus in order to learn a new concept, there must be created a successive phase of the pupils' previous experiences. We also learn that which is pertinent to our accepted goals, and this pertinency is not always easy to establish. Too often the sole authority recognized by the pupils is the text, and often the text and teacher comprise the sole authority relative to the pertinency of suggested learning activities. The value of all supplementary work is to provide a setting, a living, for the concepts to be learned. Thus if appropriate motion pictures could be devised, they could be utilized in the mathematics classroom to form a relationship with the pupil's previous experiences and increase the pupil's conception of authority for the pertinency of the suggested learning activity. This should increase the appreciation of mathematics as a tool and as a science.

Posters are another form of visual education that add to the learning atmosphere in the mathematics classroom.

The 1937 and 1938 classroom texts seem to fall into three categories. (1) Those which attempt to provide a mathematics making a contribution to other parts of the curriculum or directed toward some vocational end. (2) Those which present mathematics as a science not much concerned with the utilitarian aspects. (3) Those which incorporate both aspects by providing an organization which recognizes mathematics as a science with applications in every day living or in other parts of the curriculum. I inadvertently omitted *Clear Thinking: An Approach Through Plane Geometry* by L. H. Schnell and M.

Crawford (Harper Brothers—$1.60) which presents an organization and methodology quite different from the conventional plane geometry. I believe we shall see more books of this type in the near future.

Introductory college texts also deserve a place in such a bibliography, for much the same reason as arithmetic—that is, to provide continuity with what is to follow. Many high schools now offer a course in the senior year which parallels the introductory college course in mathematics.

Perhaps the most popular of the supplementary texts is *Mathematics for the Million* by Hogben. The popularity of this book gives evidence of the expressed adult need for more mathematics as a means of better interpreting their own lives. Perhaps this historical organization also serves as an indictment of our conventional organization of mathematics. The relatively recent social-sciencing of the secondary school curriculum has sponsored some studies to determine the utility of mathematics in the elementary social sciences. These studies should prove helpful to those attempting to secure an integration with other parts of the curriculum, and those attempting to incorporate mathematics in the core curriculum. Books by Einstein and Infeld, Bell, David Eugene Smith, and Schorling should prove helpful in providing a more meaningful and appropriate pedagogy to meet the needs of our heterogeneous population.

The Yearbooks of the National Council of the Teachers of Mathematics, serve as sources of research on topics pertinent to the teaching of secondary school mathematics. The *1936 Yearbook* was devoted to "The Place of Mathematics in Modern Education." This Yearbook incorporated the thoughts of a number of teachers in secondary school mathematics. The *1937 Yearbook* contains the thesis of Aaron Bakst on "Approximate Computation." This topic can find a place as a degree and character of emphasis to the accepted objectives of general education and has recently received impetus as an important concept in secondary school mathematics. The *1938 Yearbook* contains the thesis of H. P. Fawcett "The Nature of Proof" which contains a possible organization of plane geometry, and describes a classroom procedure attempting to achieve degrees and character of emphasis of the accepted objectives of general education. I believe that this thesis will have a profound effect upon the teaching of secondary school mathematics, and we can look forward

to similar thesis in other branches of secondary school mathematics.

Mr. Lazar produced a thesis entitled "The Importance of Certain Concepts and Laws of Logic for the Study and Teaching of Geometry." This thesis was printed in three consecutive issues of the *Mathematics Teacher* of 1938. These two theses should provide the experimentalist in plane geometry with much resource for continued experimentation. I omitted from this list of supplementary books one by M. N. Woodring and Vera Sanford entitled *Enriched Teaching of Mathematics in the High School*—Bureau of Publications—Teachers College, Columbia University—1938.

Professor Flint who has a syndicated "Brain Twizzers" in leading newspapers, has a publication containing perforated sheets which could provide enjoyment and good learning activities.

The companies offering equipment have recently added new instruments to their collection at a nominal price.

The Progressive Education Association has done a pioneering job in the construction of evaluation instruments to be used in a comprehensive evaluation program for secondary schools. The evaluation staff has accepted the setting of school subjects as stated above, and thus one can expect instruments attempting to measure, or rather to describe the individual, in light of the degrees and character of emphasis that any one part of the curriculum is supposed to achieve. One of the fundamental assumptions behind this evaluation program is that we absorb our true experiences, or learnings, and they in turn determine our future behavior. Thus evaluation becomes a problem of the interpretation of the behavior of an individual in a pre-determined setting. The evaluation instruments attempting to measure degrees and character of emphasis as fostered by mathematics have been developed under the direction of Dr. M. L. Hartung, associate director of the evaluation staff. Some of the instruments developed which are related to mathematics are:

1. The Nature of Proof
2. The Interpretation of Data
3. Problems Relating to Proof in Mathematics
4. Problems Relating to Function in Mathematics
5. Problems Relating to Functional Thinking in Mathematics.
6. Recognition of Quantitative Factors.

Along with this conception of evaluation and the acceptance of the setting of mathematics comes the development of appropriate records to record the interpreted behavior of the individual pupils. A committee of the Progressive Education Association under the chairmanship of E. R. Smith of Beaver Country Day at Chestnut Hill, Massachusetts, has developed an experimental form of a permanent record in accordance with the accepted setting of mathematics and the above concept of evaluation.

Now comes perhaps the greatest recent contribution to the secondary school mathematics—namely the commission reports. The Joint Commission is composed of a committee from the National Council of Teachers and Mathematics and a committee from the Mathematical Association of America. The Joint Commission has published their two preliminary forms this past April and July on "The Place of Mathematics in Secondary Education." The Progressive Education Association has issued a report "Mathematics in General Education" this past June. Both reports have accepted the above setting of mathematics, and view the objectives of mathematics as being the objectives of general education. Both of the reports are directed toward the same end, but the mode is quite different. The Joint Commission may be classified as favoring the "essentialist" point of view, while the Progressive Education Association favors the "functionalist" point of view—this is my own interpretation. The Progressive Education report adopts the conception of "needs" as being the guiding principle in curriculum making, but unlike other commission reports of the Progressive Education Association, they assume that certain basic understandings apply in all four of the basic aspects of living as created by the Progressive Education Association. We shall look forward to their completed final reports.

In summary, much has been done in the past two years by both the recognized leaders in the secondary field, and also by classroom teachers. There is a marked trend of increased teacher participation in curriculum construction which involves a questioning of the accepted objectives with resulting more appropriate organization and pedagogy in secondary school mathematics. This year, and the next year or two, should prove to be a banner year for secondary school mathematics since there is so much outside help by commissions devoted to finding the place of mathematics in secondary education.

NEW MATERIALS AND EQUIPMENT IN THE TEACHING OF MATHEMATICS

Arithmetic

1. Arithmetic and Emotional Difficulties in Some University Students, C. F. Rogers, *Math. Teach.*, Jan. 1937, p. 3.
2. *Arithmetic for Teacher Training Classes*, E. H. Taylor, Holt, 1937, 432 pp., $1.70.
3. Arithmetic Readiness and Curriculum Construction, B. A. Sveltz, *Math. Teach.*, Oct. 1937, p. 290.
4. A General Educator Looks at Arithmetic Readiness, C. Woody, *Math. Teach.*, Nov. 1937, p. 314.
5. *Mathematics for Elementary Schools—A Handbook for Teachers.* The University of State of New York, 1937, 192 pp.
6. National Council of Committee on Arithmetic, R. L. Morton, *Math. Teach.*, Oct. 1938, p. 267.
7. *The Psychology and Teaching of Arithmetic*, H. G. Wheat, Heath, 1937, 519 pp., $2.80.
8. Recent Trends in Arithmetic, Sister M. Marguerite, *Cath. Edu. Rev.*, p. 159.
9. *Teaching of Arithmetic in the Elementary Schools*, Vol. I, Primary Grades, R. L. Morton, Silver Burdett, 1937, 410 pp., $2.40.
10. *Teaching of Arithmetic in the Elementary Schools*, Vol. II, Intermediate Grades, R. L. Morton, Silver Burdett, 1938, 538 pp., $2.72.

Publications in Periodicals

Administrative, Philosophical, or Research

1. Achievement of Students in College Algebra Compared with the Number of Semesters of Preparation in High School, M. C. Bergen, School Science and Mathematics, Oct. 1938, p. 763.
2. Can Mathematicians and Educationists Cooperate?, R. J. Havighurst, *Math. Teach.*, May, 1937, p. 211.
3. A Comparative Study of the Scholarship Records of Students Who Major in Mathematics, R. L. Morton and L. H. Miller, School Science and Mathematics, Dec. 1936, p. 965.
4. Crises in Economics, Education, and Mathematics, E. R. Hedrick, *Math. Teach.*, March 1938, p. 109.
5. The Difficulty of the Concrete, J. B. Shouse, School Science and Mathematics, Nov. 1937, p. 937.
6. Does Mathematics Require Specialized Endowment?, *School and Society*, 1936, 44, pp. 220–24.
7. Evaluating Appreciation of the Cultural Values of Mathematics, M. L. Hartung, School Science and Mathematics, Feb. 1937, p. 168.
8. The Experiential Background as a Basis for Mathematics, *Prog. Educ.*, 1937, pp. 106–110.
9. Experimental Studies of Large Unit and Individualized Plans of Supervised Study of Secondary School Mathematics, H. R. Douglass, *Math. Teach.*, 1936, p. 387.
10. Gestalt Psychology and Mathematical Insight, G. W. Hartman, *Math. Teach*,. Oct. 1937, p. 265.
11. High School Mathematics, Whither?, W. L. Uhl, *Educ. Digest* 2: 23–25, March, 1937.
12. How Much Progress in Secondary School Geometry, J. S. Butterwick, School Science and Mathematics, Nov. 1937, p. 911.

13. Let's Face the Facts, H. R. Douglass, *Math. Teach.*, Feb. 1937, p. 56.
14. Mathematics and Intellectual Abilities, H. J. Baker, *Math. Teach.*, Oct. 1937, p. 259.
15. Mathematics on the Offense, E. J. Moulton, *Math. Teach.* Oct. 1936, p. 281.
16. Permanency of Retention of Learning in Secondary School Mathematics, H. R. Douglass, *Math. Teach.*, Oct. 1936, p. 287.
17. The Relationship Between Vocabulary and Ability in First Year Algebra, G. E. Buckingham, *Math. Teach.*, Feb., 1937, p. 76.
18. The Relationship Between Silent Reading Ability and First Year Algebra Ability, G. E. Buckingham, *Math. Teach.*, March 1937, p. 130.
19. The Relative Effectiveness of a Large Unit Plan of Supervised Study and the Daily Recitation Method in the Teaching of Algebra and Geometry, C. W. Hunziker and H. R. Douglass, *Math. Teach.*, March 1937, p. 122.
20. The Relation of High School Mathematics to College Marks and Other Facts to College Marks in Mathematics, *Sch. Review*, 1936, p. 615.
21. Preparation of Teachers of Mathematics for Junior and Senior High School, W. B. Aspinwall, School Science and Mathematics, June 1937, p. 615.
22. Sectioning of Students on Basis of Ability, F. Wood, *Nat. Math. Mag.*, Jan. 1937, p. 191.
23. Some Problems in Evaluation, M. L. Hartung, *Math. Teach.*, April 1938, p. 175.
24. Some Psychological Phases of Student Success in High School Mathematics, J. E. Allen, *Math. Teach.*, Nov. 1937, p. 322.
25. Testing the Ability to Study, J. B. Orleans, *Math. Teach.*, April 1936, p. 170.
26. Why Mathematics?, R. M. Grimes, School Science and Mathematics, April 1936, pp. 426–27.
27. Why We Teach Mathematics, K. P. Williams, *Math. Teach.*, Oct. 1936, p. 271.

Curricular

1. The Abstract and Concrete in the Development of School Geometry, George Wolff, *Math. Teach.*, Dec. 1936, p. 367.
2. Application of Professional Treatment of Logarithms, Eucebia Shuler, School Science and Mathematics, Oct. 1937, p. 782.
3. Algebra as a Language, A. A. Bennett, *Math. Teach.*, Nov. 1937, p. 307.
4. Calculating Machines and the Mathematics Teacher, E. M. Norton, *Math. Teach.*, Oct. 1937, p. 271.
5. The Conic Compass, J. L. C. Lof, School Science and Mathematics, Nov. 1938, p. 842.
6. Finding Social Mathematics in School Activities, Dorothy Noyes, *Math. Teach.*, Nov. 1936, p. 340.
7. Geometry—A Way of Thinking, H. C. Christofferson, *Math. Teach.*, April 1938, p. 147.
8. Geometry and Life, K. B. Leisenring, *Math. Teach.*, Nov. 1937, p. 331.
9. Geometrical Derivation of the Formulas for the Solution of the Oblique Triangles, J. J. Corliss, School Science and Mathematics. June 1937, p. 675.

10. Geometric Representation of the Terms of Certain Series and Their Sums, A. Struyk, SCHOOL SCIENCE AND MATHEMATICS, Feb. 1937, p. 675.
11. Home Economics and Mathematics, R. Schaeffer, *Pract. Home Econ.*, 14: 37, Feb. 1937.
12. Is There Any Use for Imaginary Numbers?, P. N. Nygaard, SCHOOL SCIENCE AND MATHEMATICS, March, 1937 p. 257.
13. The Importance of Certain Concepts and Laws of Logic for the Study and Teaching of Geometry, N. Lazar, *Math. Teach.*, March, April, May, 1938.
14. Mathematical Analysis of Social Sciences, A. C. Rosander, *Math. Teach.*, Oct. 1936, p. 289.
15. Mathematics—A Tool Subject or a System of Thought, F. L. Griffin, *Math. Teach.*, May 1937, p. 223.
16. Mathematics and Science, C. N. Moore, SCHOOL SCIENCE AND MATHEMATICS, Jan. 1938, p. 41.
17. Mathematics and the Imagination, W. D. Reeve, *Teacher College Record*, April 1937, p. 593.
18. Mathematics Functioning in Industry, R. F. Forbes, SCHOOL SCIENCE AND MATHEMATICS, May 1937 p. 513.
19. Mathematics in Junior College, J. S. Georges, SCHOOL SCIENCE AND MATHEMATICS, March 1937, p. 302.
20. The Mathematics of the Automobile, *Math. Teach.*, May 1938, p. 209.
21. Mathematics in the Modern Curriculum for Secondary Education, W. L. Wrinkle, *Math. Teach.*, Dec. 1936, p. 337.
22. Mathematics Through Social Situations, C. M. Saunders, *Educ. Methods*, 15: 352–55, April 1936.
23. On the Study of Mathematics, F. W. Bubb, SCHOOL SCIENCE AND MATHEMATICS, June 1938, p. 639.
24. The Place of Mathematics and Its Teaching in Schools of This Country, J. Seidlin, *Nat. Math. Mag.*, Oct. and Dec. 1936, pp. 24–25 and pp. 147–151.
25. The Place of Plane Geometry in the Secondary School Curriculum, C. A. Stone, SCHOOL SCIENCE AND MATHEMATICS, Jan. 1937, p. 72.
26. Professional Treatment of Freshman Mathematics in Teacher's Colleges—Part I, Eucebia Shuler, SCHOOL SCIENCE AND MATHEMATICS, April 1937, p. 464.
27. A Re-definition of Secondary School Mathematics, L. H. Schnell, *Math. Teach.*, Jan. 1936, p. 14.
28. The Significance of Mathematics in the Physical Sciences, Louis Brand, SCHOOL SCIENCE AND MATHEMATICS, June 1938, p. 607.
29. The Social-Civic Contributions of Mathematics, L. B. Kinney, *Minn. Jour. of Educ.*, 1936, p. 141.
30. The Sources of Euclid, N. E. Rutt, *Nat. Math. Mag.*, May 1937, p. 374.
31. Sundial—A Mathematics Unit, E. Wood and F. M. Lewis, *Teach. College Record*, 37: 618–24, April 1936.
32. A Unique Mathematics Exhibit, Ruth Wilson, *Math. Teach.*, March 1937, p. 128.
33. A Unit of Statistics in Ninth Year Mathematics—An Experiment, *High Points*, Sept. 1936, p. 16.
34. Uses of Certain Topics in Algebra, L. E. Boyer, SCHOOL SCIENCE AND MATHEMATICS, Nov. 19?8, p. 921.
35. What Need for Mathematics in Grade VIII?, *School Review*, Oct. 1937, p. 592–601.

Pedagogical

1. Activity in Mathematics—The Slow-moving Pupil, V. S. Mallory, *Math. Teach.*, Jan. 1936, p. 23.
2. A comparison for Finding the Interest Rate in Installment Payment Plans, H. F. Stelson, *Nat. Math. Mag.*, Jan. 1937, p. 172.
3 The Development of the Teaching of Geometry in Germany, Georg Wolff, *Math. Gazette*, May 1937, p. 82.
4. Diagnostic and Remedial Teaching in First Year Algebra, G. E. Buckingham, *J. Ed. Research*, 1936, 30: 198–212.
5. Economics Found in a Half Century's Teaching of Mathematics, J. V. Collins, *Math. Teach.*, April 1936, p. 181.
6. Generalization as a Method in Teaching Mathematics, R. M. Winger, *Math. Teach.*, May 1936, p. 241.
7. Improving Ability in the Mathematical Concepts of Educational Statistics, *Jour. Ed. Psych.*, 1937, p. 461.
8. Individualized Instruction in Algebra, D. W. Snader, *Math. Teach.*, April 1937, p. 167.
9. Methods for Teaching Special Products and Their Factors in Ninth Grade Algebra, E. G. Howland, School Science and Mathematics, Oct. 1936, p. 721.
10. Must all Mathematics Be Forgot?, F. R. Powers and A. W. Engle, School Science and Mathematics, Nov. 1938, p. 871.
11. Number and the Four Fundamental Operations in Arithmetic, G. James, School Science and Mathematics, Dec. 1937, p. 1025.
12. Observations on the Study and Teaching of Mathematics, E. T. Browne, *Math. Teach.*, April 1937, p. 147.
13. Solid Geometry Made More Interesting, M. C. Volpel, School Science and Mathematics, Oct. 1938, p. 740.
14. Teaching for Transfer of Training, E. R. Hedrick, *Math. Teach.*, Feb. 1937, p. 51.
15. Teaching of Solid Geometry at the University of Vermont, G. H. Nicholson, *Math. Teach.*, Nov. 1937, p. 326.
16. Teaching the Subtraction of Signed Numbers, M. W. Tate, School Science and Mathematics, Oct. 1937, p. 837.
17. Transfer of Training and Reconstruction of Experience, P. T. Orata, *Math. Teach.*, March 1937, p. 99
18. Trends For Improving Instruction in Mathematics, H. C. Christofferson, *Math. Teach.*, Jan. 1937, p. 15.
19. The Utility of Analytic Geometry Concepts to Secondary School Teachers of Mathematics, Science, and Industrial Courses, *Jour. Exper. Educ.* 1937, pp. 356–367.

Supplementary Available Motion Pictures

1. Mechanical Intricacies of Burroughs Adding Machines, Burroughs Adding Machine Company.
2. The Development of Astronomical Knowledge, 1 reel, silent, 75¢ per day, Bureau of Visual Educ., Univ. of Wis., Madison, Wis.
3. Dynamic Learning (W. H. Kilpatrick), 2 reels, sound, $2.50 per day, Univ. of Wis.
4. Dynanic Symmetry, 41 plain slides, Indiana Univ. Extension Division, Bloomington.
5. The Earth in Motion, 1 reel, sound $1.25 per day, Univ. of Wis.
6. Einstein's Theory of Relativity, 2 reels, silent, $1.50 per day, Univ. of Wis.
7. The Evolution of the Universe, 1 reel, silent $.75 per day, Univ. of Wis.

8. Exploring the Universe, 1 reel, sound, $1.25 per day, Univ. of Wis.
9. Frequency Curves, 1 reel, silent, 75¢ per day, Univ. of Wis.
10. Geometry (1932), Charles H. Sampson, 320 Huntington Ave., Boston, Mass.
11. Gravitation: the Moon; Constellations, 1 reel, silent, 75¢ per day, Univ. of Wis.
12. Light Waves and Their Uses, 1 reel, sound, Univ. of Ind.
13. The Moon, 1 reel, sound, $1.25 per day, Univ. of Wis.
14. Parabola, 16 mm. and 35 mm., sound, $10.00 per occasion, abstract design which links together in a new dramatic visual theme art, mathematics and education, Rutherford Boyd, 112 Prospect St., Leonia, N. J.
15. The Play of the Imagination, 1 reel, sound, $1.25 per day, Univ. of Wis.
16. Preview of Mathematives via Movies, released in 1933 for use in ninth grade algebra, silent, State Teachers' College, Upper Montclair, New Jersey.
17. Resolution of a Vector into Components, released in 1935 for use in college physics, Dept. of Physics, Univ. of South, Sewanee, Tennessee.
18. The Solar Eclipse of Aug. 31, 1932, 1 reel, silent, 75¢ per day, Univ. of Wis.
19. The Solar Family, 1 reel, sound, $1.25 per day, Univ. of Wis.
20. Sound Waves and Their Sources, 1 reel, sound, $1.25 per day, Univ. of Wis.
21. The Sun: Its influence on the Earth, 1 reel, silent, 75¢ per day, Univ. of Wis.
22. Teaching with Sound Films, 1 reel, sound, $1.25 per day, Univ. of Wis.
23. Through the Kaleidoscope, ½ reel, silent, Univ. of Kan., Lawrence, Kan.
24. Visualized Solid Geometry, 2 reels, silent, $1.50 per day, W. Thornton, Central Senior High School, 317 W. Wash. Avenue, South Bend, Ind.
25. Weather Forecasting (For interpretation of data), 1 reel, silent, 75¢ per day, Univ. of Wis.

Literature on Motion Pictures

1. Exhibition of Mathematical Films, *Math. Gazette*, Vol. 20, 1936, pp. 110–114.
2. *How to Use the Educational Sound Film*, M. R. Brunstetter, 1937, 174 pp., Univ. of Chicago Press.
3. Mathematical Films, Margaret Purnett, *Math. Gazette*, 21; May 1937, pp. 149–151.
4. Motion Pictures in Education, A Summary of the Literature Am. Council on Educ. Comm. in Motion Pictures in Educ. Edgar Dale, H. W. Wilson, 1937, 372 pp., $2.50.
5. Slides and Films Relating to Mathematics and Its Application, E. H. C. Hildebrant, *Am. Math. Mon.*, Oct. 1938, p. 548.

Posters

1. Illustrations Depicting the Use of Mathematics in the Motor Car Car Engineering, Educational Service Department, Chevrolet Motors Division, General Motor Sales Corporation, General Motors Building, Detroit, Michigan.
2. Portraits of Eminent Mathematicians, Portfolio II, D. E. Smith, *Scripta Mathematica* XIII Folders, $3.00, 1938.

3. Portrait of Pythagoras from a Fresco by Raphael, 6¢ in stamps, *Scripta Mathematica.*

Puzzles

1. *Brain Twizzers,* Prof. Flint, P. B. Publications, Chicago, 1938, 50¢.
2. *The Canterbury Puzzles and other Curious Problems,* H. E. Dudney, Thomas Nelson and Sons, 1938, $1.50.

Equipment

1. Boyce-Meier Equipment Co., Dept. K., Box 281, Bronxville, N. Y Transit, Level, and Sextant
2. The Lafayette Instruments, Inc , 140 N Market St., East Palestine, Ohio, recently added some new instruments.

Evaluation Instruments

1. Evaluation instruments as developed by the Evaluation Staff of the Prog. Educ. Assoc., Evaluation in Math. under direction of M. L. Hartung, 6010 Dorchester Ave., Chicago.

Records

1. Permanent Record Card in Mathematics, Reports and Records Comm. of Prog. Educ. Assoc., E. R. Smith, chairman, Beaver Country Day School, Chestnut Hill, Mass.

Commission Reports

1. Joint Commission of National Council of Teachers of Mathematics and Mathematical Association of America, K. P. Williams, Chairman, Indiana Univ. Bloomington, The Place of Mathematics in Secondary Education, Prel. forms 1938.
2. Prog. Educ. Assoc. Commission report, Mathematics in general education, M. L. Hartung, Chairman, U. of Chicago, Preliminary Report. 1938.

SUBMARINE FOR SCIENTIFIC RESEARCH

One submarine in all the world's bristling array of deadly steel fish has been dedicated to the peaceful work of science. In May, Her Majesty's submarine O-16 of the Netherlands Navy will leave for the East Indies on a new extensive gravity expedition sponsored by the Netherlands Geodetic Commission.

The ship will be commanded by Lieut.-Comdr. B. C. Meurs and the research will be carried out by Dr. W. Nieuwenkamp. This will consist of further investigations of differences of the gravitational pull exercised on different regions of the sea botton. These differences, or gravitational anomalies as they are called, are due to varying densities in the earth's crust beneath the ocean bottom.

A submarine is necessary for this work because the complex pendulum which is the chief apparatus used must have a steady platform, and the submarine can dive beneath the zone of waves and other surface disturbances which would make the work impossible on an ordinary ship.

The method of gravity investigation to be used on the forthcoming research voyage was developed by Dr. F. A. Vening Meinesz and was used by him on similar voyages in recent years.

A SELF-IMPROVEMENT SHEET IN BIOLOGY TEACHING IN THE SECONDARY SCHOOLS

ERNESTINE W. ROBERTS
Terre Haute, Indiana

[It is to be noted that in a paper of this type the different evaluations are subject to opinion and the evaluations given are not necessarily the correct ones. The set-up and method of the author are highly commended. It will be stimulating for the reader to make his own evaluations and attempt to justify them in cases in which these differ from those given. Biol. Ed. note.]

BRIEF HISTORY OF IMPROVEMENT SHEETS

The history of self-improvement sheets is a comparatively short one. The first practical application of the principle of self-analysis and self-improvement was probably set forth by Carl Franzen of Indiana University. As early as 1926 he stated that: "When satisfactory Improvement Sheets have been worked out in each system, the busy principal has truly accomplished the task of supervision, for under his sympathetic guidance and counsel his teachers have become supervisors of themselves."[1] In 1932 Franzen made a self-improvement sheet in Algebra.

W. T. Melchior, professor of Educational Supervision at Syracuse University in Syracuse, New York, made the next notable advance along the line of self-improvement. He presented a very dynamic paper to the National Education Association in 1934. He advocates that a self-improvement or self-supervisory sheet will liberate teachers and will aid each one to become efficient in self-analysis, self-criticism, and self-supervision. He says, "A practical way out is to substitute self-supervision for, at least certain types of, supervision."[2]

J. R. Shannon, Indiana State Teachers College, has followed closely in the steps of Franzen. He has written several such sheets in various fields that have not been published. The only published self-analysis sheet that he has made is one in the field of geography. Shannon agrees with Melchior, "The principle value of the self-supervisory sheet is to make the teacher more circumspect in her own teaching."[3]

---

[1] Carl Franzen, "Plans for the Supervision of High School Teaching by the Busy Principal." Bulletin: *School of Education of Indiana University*. Vol. 3, p. 16. November, 1926.

[2] William T. Melchior, "Self-Supervision by Teachers—A Practical Way Out." *N.E.A. Proceedings*. Vol. 72, p. 685. February, 1934.

[3] J. R. Shannon, "A Self-Analysis Sheet in Geography." *Journal of Geography*. December, 1934, p. 346.

As far as the writer knows, no similar sheet has been made in the field of biology, and, realizing the need for such a sheet, has endeavored to compile a self-improvement sheet in biology teaching in the secondary schools.

The Problem

This study was made to determine the relative importance of various teaching procedures, methods, and techniques; to compile and evaluate these methods and techniques, and to discover in what way they relate to the success or failure of the teacher of biology in the secondary schools.

It is the purpose of the writer to formulate a device which will lessen the duties of the so-called "special" supervisor, and will make the teacher more critical of her own teaching procedures.

Method of Approach

In formulating a self-rating device for the improvement of biology teachers, it was decided that probably the best method or technique to use was that of massed opinion. The questionnaire was used to secure the desired information.

Five hundred questionnaires were sent out to the various teachers of the subject throughout the United States. Only one hundred twenty-three of these were returned in time to be included in the study. The items of the questionnaire were compiled from a large number of experts in the field of biology and education. Here, the most widely used textbooks of methods in biology and articles published in the current periodicals in the field were used. One hundred sixty-three of these were of superior quality, and, so, were used in compiling the desirable teacher activities, believed to result in pupil activity, and thus in teacher improvement. These references are found in the bibliography of the study.

Procedure

Accompanying the questionnaire were the directions to rate the items of the questionnaire according to maximum and minimum and average importance. The items considered to be of maximum importance were to be marked with a (1) and those of minimum importance were to be marked with a (3). All items left unmarked were to be considered, by the writer, to be of average importance.

In evaluating the items of the improvement sheet the writer, first, attempted to rank these according to the frequency with which they were marked. Then Spearman's Formula was used:

$$R=1-\frac{6\sum g}{n^2-1}.$$

It was found that the correlation was very low, being only .125; thus it became necessary to rank the items according to the frequency of both the 1's and the 3's (those of maximum and minimum importance). Here the items were ranked according to weights.

The weight of each item was found by subtracting the frequency with which it was rated by 3's from the frequency with which it was rated by 1's, or, the number of 3's of each question was subtracted from the number of ratings by 1's that the same item received. It was decided to let the entire questionnaire be based on one thousand points (1,000).

The weights of all of the items of the questionnaire were found by taking the sum of all of the individual weights. This was found to be five thousand seven hundred thirty-eight (5,738) points. Therefore the point value of each item would be equal to 1/5,738 of 1,000 multiplied by the frequency with which it was ranked according to weights. For example, item *one* received *112* first rankings and *one* third ranking, therefore the weight of each item would equal 111, that is, the ranking by 3's subtracted from the ranking by 1's. Then the point value of item *one* would equal 0.174 (1/5,738 of 1,000) times the frequency with which it was ranked; this was 111. Then the point values in thousandths becomes 19.314. It was decided to take the numbers to the next highest integer if the decimal was more than one-half (.5), and to drop the decimal if it was less than one-half (.5). In this instance the decimal was dropped and the value of item *one* became 19.

Results of the Study

To make the self-improvement sheet usable for teachers of biology, the writer has listed the items of the sheet and given their point value as found from the self rating scale. These are indicative of the importance of the item.

The original questionnaire contained one hundred eight items, but due to the very evident unimportance of some of

the items, questions "4," "11," "78," "82," "94," and "96" were omitted from the final sheet. The basis of these eliminations was made on a resulting computation of a negative value in evaluating the items.

The questions of the Improvement Sheet may be answered by *yes* or *no;* in every instance, the positive answer is the favorable one. The degree and extent to which a teacher uses the sheet is dependent upon her alone.

SELF-IMPROVEMENT SHEET IN BIOLOGY TEACHING IN THE SECONDARY SCHOOLS

Objectives in Biology Teaching

a. To bring about in the biology class a learning situation which is closely related to the pupils' welfare.
b. To provide the pupils with the facilities to explore various fields in relation to vocational and occupational guidance.
c. To aid the pupils in the understanding of the phenomena of their immediate environment and to develop the power of observation.
d. To develop an interest in the plants and animals, and an appreciation of nature which will be enriched by the pupils' biological experience.
e. To provide learning situations that will develop thinkers and a scientific attitude.
f. To provide for some, a basis for a more comprehensive study of the biological sciences on the professional level.

Organization of Subject Matter

1. Is the teacher's course well planned in advance?............ 19
2. Does she decide upon the minimum essentials for the year?..... 10
3. Does she know the source of all her materials, i.e., city library, school library, biology department, etc.?.................. 13
5. Does she divide her minimum essentials into suitable units?.... 8
6. Does she know the pupils' backgrounds?................... 8
7. Does she organize the course around the pupils' environmental conditions of the community?.......................... 11
8. Does the teacher arrange her course by seasons?............. 11
9. Is sex education a part and a portion of the whole biological course?.. 4
10. Does the teacher arrange her course about the interest of her pupils?.. 9

Presentation of Subject Matter

12. Does she give the pupils the fundamental principles common to all living things?.................................... 16
13. Does she begin teaching something well-liked by all, such as butterflies, plants, birds, etc.?........................... 5
14. Is the biological subject matter, and are the methods of teaching adapted to the capacity of the pupils?.................... 16
15. Does the teacher begin each new unit or lesson with some challenging problem?.................................... 8
16. Does the teaching meet all of the health needs of the community?. 2
17. Does the teacher place a special emphasis on the economic importance of the fauna and flora?........................ 2

18. Are the lessons correlated with the occupational needs of the community?.. 1
19. Does the teacher teach along the lines of her pupils' interests?.. 6
20. Where the pupils' interests vary, does the teacher assign individual projects?.. 9
21. In the demonstration lesson does the teacher lead the pupils to definite conclusions by a series of well-worded questions?...... 11
22. Does the teacher make use of drawings on the board to illustrate ideas?.. 14
23. Does she make use of drills to instill principles and their application?.. 5
24. Does she have a varied knowledge of the plant and animal life to present to the pupils?.. 17
25. Is the subject matter presented on the level with the learner?... 15
26. Does the teacher avoid becoming monotonous and dull by not remaining on one subject too long?.......................... 9
27. In the lecture-demonstration-recitation does the teacher present her subject in such a way as to leave a permanent impression on the pupils?.. 12
28. Does she first present her topics as a whole, and than analyze them into their parts?.. 4
29. Does she systematize her knowledge, making clear all relationships of the part to the whole?........................ 10
30. Does the teacher have a scientific approach?.............. .. 12
31. Does she set up situations for questions as well as questioning?.. 11

Motivation

32. Are the pupils allowed to follow up their own interest in the classroom and outside?..... 10
33. Can the teacher inculcate the desired interest in the beautification of the homes through her teaching?...................... 4
34. Is pupils' interest maintained and sustained throughout the class period?.. 15
35. Does the teacher have enthusiasm, interest, sincreity, and initiative in the subject?.. 20
36. Are the assignments varied from day to day in such a way that they arouse curiosity on the part of the learner?............. 8
37. Does the teacher exhibit the work of a better quality of her pupils? 4
38. Does the teacher make use of visual aids to motivate her work?. 15
39. Does she activate interest on the part of the students by the organization of clubs and the making of scrapbooks, etc.?..... 5
40. Does the teacher encourage the students to collect specimens when they see them?.. 13
41. Does she give extra credit for collections which are brought in?. 4
42. Are the pupils commended for successful attainments and effort? 14
43. Does the field trip activate the pupils?...................... 10

Field Trips

44. On the field trip does the teacher have an orderly group?...... 14
45. Has she visited the place of the excursion prior to the trip?.... 14
46. Does she have the field trip well organized?.................. 16
47. Does the field trip have a definite purpose?.................. 19
48. Has the teacher found the problems for investigation?......... 8
49. Does the teacher leave each pupil as largely self-directive as possible?.. 7

50. Does each pupil have a definite thing or things to see while on the trip? 8
51. Does the teacher bring in material for future work? 7
52. Are the pupils acquainted with the fauna and flora of their locality? 8
53. Does the teacher collect quite a bit of her own material? 6
54. Does she show the pupils the source of her material? 5
55. Does she see that the material is sorted and labelled when they return from the trip? 7

Visual Aids

56. Does the teacher use lantern slides to explain points which are not clear? 7
57. Does the teacher make use of the motion picture machine? 8
58. In the use of the motion picture machine does the teacher give the child the proper mental set the day before? 4
59. Does the film appea to the socially approved interests of the pupils? 2
60. Is the film one which will really attract attention? 7
61. Does the film create a problem in the observer that requires mental activity for solution? 6
62. Are still pictures used in connection with the stereopticon? 2
63. Are microscopes, hand lenses, and binoculars used to study the most minute details? 11
64. Are the pupils held responsible for visual material that is shown? 9
65. Does the teacher use visual material only as a last resort, i.e., only when living biological specimens are not available? 2

Project Teaching

66. Does the teacher encourage individual problems and projects? 17
67. In this problem solving does the problem or the project have a direct relation to the work of the classroom? 7
68. Is the project a purposeful, concrete problem, the solution of which is executed by the pupils? 11
69. Is the project a means of directing the thinking of the individual? 13
70. Does the teacher guide and direct the individual projects rather than assign projects of her own with hard and fast rules to go by? 8
71. Does the teacher develop a scientific attitude and scientific methods of thinking in her pupils? 14
72. From time to time, does the teacher place the completed projects on display? 8
73. Does the teacher include the project in the other work of the term in grading the pupil? 8
74. Does the project stimulate the child to thought along other lines? 8

Pupil Activity

75. Do the pupils participate in the recitations, discussions, and demonstrations when the proper time arrives to do so? 18
76. Are the pupils allowed to display initiative through questioning and oral reports? 16
77. In the problem-solving method of teaching, do the pupils, themselves raise the problems? 8
79. Are the pupils encouraged to collect any other material that may be used later? 10

80. Does the teacher allow socialization of the recitation by allowing the pupils to lead in the discussion? 9
81. Do the pupils react favorably to tests, i.e., is pupil activity more pronounced after administering a test? 6

Supplementary Teaching Aids

83. Does the teacher make use of charts and graphs? 14
84. In the teaching of the geographical distribution of plant and animal life, does she use various maps? 8
85. Does her bulletin board contain authentic accounts of newspaper material? 10
86. Does she have exhibits of the life histories of harmful and helpful plants and animals? 12
87. Does she make use of diagrams, charts, and models to put her lesson across? 14
88. Does the teacher make use of the City Health Department, Water Supply, Dairy, etc., for trips? 8
89. Does the teacher make use of pamphlets from various manufacturing concerns, the Federal Government, State Board of Health, etc.? 12
90. Does the teacher encourage visits to the museum? 11
91. Does she make use of various references rather than of one or two? 13
92. Does the teacher maintain an aquarium, herbarium, and a terrarium? 15
93. Does the teacher encourage the attendance of lectures and the reading of outside books? 10
95. Does the teacher attempt to develop hobbies in the students by playing up to the collective habit? 7

Correlation with Other Subjects

97. Does the teacher advocate the use of the best possible English? .. 17
98. Are all of the written reports required to be in some special form, preferably that used by the English department? 3
99. Is the scientific method of thinking which is developed in the biology classroom carried over into physics, chemistry, and other subjects? 10
100. Are the basic principles of biology applicable in the home economics class? 9
101. Does the biology course work in harmony with every other course in the school? 12

Tests and Measurement

102. Are questions on the coming assignment cleared up before the class is dismissed? 13
103. Does the teacher make use of all sorts of measuring devices, i.e., objective tests, essay tests, true-false, and completion, etc.? 13
104. Does the teacher base her teaching on the weaknesses found in the tests? 8
105. Are the tests well worded? 13
106. Do the tests determine the needs of the pupils? 7
107. Do the tests motivate the pupils to further study? 10
108. Does the teacher develop thinking on the part of the learner by her tests? 13

SOME EFFECTIVE SCIENCE ACTIVITIES IN THE UPPER ELEMENTARY GRADES

MILDRED FAHY
Peirce School, Chicago, Illinois

(This article is the third of a series of four articles of practical interest to elementary science teachers. Miss Fahy is the Principal of the Peirce N. E. A. and has had several years of experience in promoting the teaching of elementary science. The activities she describes have been used and have proved successful.

The first article of the series entitled "Adding Interest to the Elementary Science Classroom" by Dorothy Phipps appeared in the March issue. The second article gave suggestions for the care and handling of pets in the classroom and appeared in the April issue. The fourth and last article of the series will deal with science activities in the primary grades and will be in the June issue. D. W. R.)

A growing consciousness of the importance and values of science in the elementary school has brought problems to teachers and administrators. Science is definitely coming into the elementary school and its presence there and its successful handling by teachers is helping to change the approach to science in the high school and perhaps even at the college level. If the best way to teach any subject were known, many of the problems of dealing with education could be solved at once. But so long as individuals retain their personalities and children are children, the quest for ways of interesting them will never grow old. It is quite natural for people and children to wonder why things happen. The teacher can always take this normal curiosity and turn it to the advantage of solving a problem.

Principles in their cold state have little interest for children. Making a telegraph set requires certain information and slight skills. The child's delight when it "clicks" brings about the understanding of a principle. The various ways he tested his ideas of the circuit gave him the incipient stages of using scientific method and true thinking. The determination of subject matter in the upper grades is not agreed upon by everyone. But if science is taught in the elementary school with the aim of understanding and observing features of the environment, the material should follow a definite seasonal plan. Autumn should bring a study of trees since they are preparing for their resting period in the winter and the future establishment of their own kind is so well demonstrated. Bulb planting is an interesting activity which should not be overlooked. The sky offers such

a festival of bright stars in the winter that one can scarcely avoid its careful study. Magnetism and electricity, light and heat for indoor work should be followed during the winter months. If no other provision be made for a health program, the winter months also offer a period for studying health. The awakening of life in the spring may suggest the study of plant life and birds.

The science teacher today has at her disposal an enormous number of activities which the children can carry on outside school. These activities can easily become the new type of homework and at the same time, they develop many useful hobbies which children love to have for the future. Following are a few suggestions for planning the elementary science program in the upper elementary grades.

Physiology

This subject is especially adaptable to the interests and attitudes of eighth graders. Below are described some of the more successful activities.

Make clay models of organs of the body; use charts of the systems of the body; make the circulatory system from glass tubing; construct a skeleton from wood; use shadow posture pictures; make a cross-section of a tooth-chart from clay or wood; use food charts of mineral containing foods; discuss and use charts of well-balanced meals; give examples to show the work of the muscles of the body; give examples of joints and their types, discuss antidotes of poisons that are common; study methods of preserving food; collect patent medicine labels designating false claims; make a health survey of the neighborhood; experiment with white rats and mice; work with a model of the lung or measure lung capacity by displacement of water in a jug.

Flowers and Seeds

Many of the following suggestions will help to stimulate science activities in the spring.

Make a map of the United States with state flowers; cut out chart of parts of flower; construct a woodland scene with wild flowers in natural habitat; collect flower poems and stories; show how certain national flowers were chosen; investigate where flowers got their names; collect pressed or waxed flowers; collect flowers pollinated by bees, moths, wind, flies; make flower designs for wall paper, cloth, etc.; make small glass seed germination testers (glass, blotter, seeds) such as a rag doll tester; use a germination chart to compare corn and beans; make a chart of the parts of seed; make a cold frame and a hot box; make a tiny greenhouse; try dirtless "farming" using various kinds of soils; use erosion-models of means of prevention.

Plants

Activities of this kind also stimulate interest in children in the upper elementary grades.

Collect seed of wild and cultivated flowers, trees, seeds used for food; show different types of dispersal; use charts with types of roots, food charts from different parts of plants, and chart of textiles from plants, e.g. cotton; grow plants from cuttings, stolon, etc.

Fire

Activities related to fire are both interesting and useful for general understanding of environment. Interest need not be stimulated but guidance is important.

Make model of devices used to make fire from earliest times on, such as the fire bow, burning glass, etc.; make a fire hazard score card of the home; make a simple extinguisher and use it; collect fire proofing material; make a map of fire boxes in neighborhood and school; collect newspaper articles on fires and suggest as to how they might have been prevented; collect forms of carbon; make charts of uses of fire and uses of coal and coke and other fuels; make oil derrick or a diorama of oil fields; collect fuels and materials that will and will not burn.

Sky Study

Children of most ages enjoy the mystery of sky study. Below are some suggestions to meet these interests.

Make star charts (luminous star charts are especially fascinating); draw charts to show cause of change of seasons; construct planet charts using balls or clay for planets; sketch constellations and study the related mythology; diagram phases of moon over a period of a month; make slides of constellations with and without mythological figure; demonstrate umbrella representation of the sky; cut out a diorama of sky over a city; have students write stories of visits to other planets.

Air, Water, and Heat

There are many activities of interest to children related to these fundamental subjects that are practical, and useful. Below are a few suggestions that will lead to others.

Make a model pump; make a kite, glider, or plane; make a working model of a windmill; make a barometer, aneroid, mercuric, or light bulb; draw charts showing the composition of the air; make and use a siphon; make a model room with air currents represented by ribbons.

Make a sand or charcoal filter; make soap; make a water wheel; make a water cycle chart; make a diagram to show the course of water from source to the home; boil and distill water.

Make a series of drawings showing the history of stoves; use a model of a hot water heating system; chart sources of heat; give examples of good and poor conductors of heat; make a simple thermometer; trace oil and coal back to the sun using illustrations and diagrams.

Trees

Just identifying trees is not the only activity of interest. The activities listed below have been tried with successful results.

Make plaster casts of leaves; make ink prints of leaves; shellac leaves and make spatter prints and blue prints; collect forest products, tree seeds, bark and twigs; collect the products of pine trees and refer to chemical products of trees; make a stick alphabet; make a chart of twigs.

Birds

Among the interesting spring and fall activities are those related to birds. General concepts can be included in bird activities. Following are a few suggestions.

Make clay models of birds; draw life sized pictures of them; make notebooks with pictures, descriptions, and general information; mount a bird skeleton; build bird houses; construct a feeding station; collect nests in the fall and mount them with pictures of the birds; build bird bath; make chart showing travels of birds during migration; make a map of bird banding stations; collect feathers; draw a bird clock of arrival of birds; draw an illustration of bird habitat.

Electricity and Magnetism

Most children use electricity every day and find magnetism an essential part of their toys. Usually activities in this field have almost permanent interest.

Make a magnetic compass; make conductivity tester with batteries; wind a magnetizing coil; assemble a simple electric motor; make an electric buzzer; construct a simple telegraph key and sounder; use a microphone.

Make a crystal radio set or a one-tube receiver; build an electric questioner; make a burglar alarm; make a stop light; make electro-magnets; make blue prints of magnetic fields.

Sound

Sound plays an important part in children's lives. Activities in this field are easily related to other activity fields.

Make an Indian signal drum; use megaphone and explain its principles; construct a string telephone; make a stick violin; build a cigar box violin or ukulele; play a rubber band harp; construct a xylophone of wood or metal; make drinking glass chimes; make a wood whistle; make a test tube organ; practice bird call; use pitch testing boards; make a simple phonograph; play a tambourine.

Light

This subject relates not only to the topic itself but to use of light. Now that the camera fad is reaching is peak the subject of light is taking on even greater interest for children.

Models of lighting devices from the torch to modern equipment; make a periscope; build a pin-hole camera and take a picture with it; look through telescopes; build a telescope if material can be obtained; make a model search-light; study the flood lights and foot lights of the school auditorium; make color mixing wheel; make a spectrum chart; show effect of color on rooms in a model house; make a kaliedoscope; relate light as much as possible to the "candid camera" fad.

Weather and Climate

Besides being a subject we continually talk about but do little about, activities related to this topic are numerous and have many practical aspects. A few suggestions follow.

Construct an anemometer; build a weather vane; make a rain gauge and use it; make a chart of kinds of clouds using cotton for clouds; show by use of maps or charts the effect of different kinds of climate; collect pictures showing the effect of wind; collect weather proverbs and discuss them.

Better habits of thinking through simple problems and a knowledge of how to perform simple experiments will pay the way for an emphasis on life situations and the use and understanding of things at hand for the boy and girl. Many of the activities suggested in this article will help to serve this end in science teaching.

COLLEGE EXTENSION COURSES TO BE OFFERED ABOARD ROTTERDAM

A pleasant way of taking college extension courses—and obtain college, graduate or "Teacher" credit for them—is now available on the S.S. ROTTERDAM, Rio-bound on its 53-day Cruise in connection with the Eighth Biennial Congress of the World Federation of Education Associations August 6th to 11th. Three such courses will be available for those interested, it is announced by Dr. Paul Monroe, President of the W.F.E.A., offered respectively by Clark University and Indiana University. In each case, they will be the equivalent of courses offered at the universities' regular summer sessions.

Clark University, well recognized in the field of Geography, is offering Geography of South America, and Geography of Caribbean America, including economic and other problems as well as physical characteristics. Dean Henry Lester Smith of Indiana University, a Director of the Federation, will for the fourth summer offer a course in Comparative Education while en route to the Conference of the World Federation of Education Associations aboard the ROTTERDAM.

Inquiries regarding the credits available for these courses, and all inquiries regarding either the ROTTERDAM or the short summer Cruise to Rio on the S.S. ARGENTINA, should be addressed to the World Federation of Education Associations headquarters, 1201-16th St., N.W., Washington, D. C.

EASTERN ASSOCIATION OF PHYSICS TEACHERS

One Hundred Forty-first Meeting

BOSTON COLLEGE

Chestnut Hill, Mass.

Saturday, March 4, 1939

9:45 Meeting of the Executive Committee.
10:00 Report of the New Books and Magazine Literature Committee.
Mr. Richard Porter-Boyer, Chairman.
10:10 Report of the Delegate to the American Science Teachers' Association, and to the National Educational Association.
Mr. Homer W. LeSourd.
10:20 Report of the Committee to formulate a "Minimum Syllabus" in Physics for College Entrance.
11:00 Address: "Concepts of the Atom."
Dr. Frederick E. White, Boston College.
12:00 Address and Demonstration: "Apparatus for Measuring the Electronic Charge, and the Charge-mass Ratio."
Prof. F. Malcolm Gager, Boston College.
1:00 Luncheon.
2:00 Greetings: (Rev.) William J. McGarry, S.J., Ph.D., President of Boston College.
2:10 Address: "The Acoustics of Auditoriums and Class Rooms."
Prof. Philip M. Morse, Mass. Inst. of Technology.
2:50 Address: "Some Reflections on the Teaching of Physics."
Prof. Robert B. Lindsay, Chairman of the Department of Physics, Brown University.
3:30 Visit to the laboratories of Boston College.

OFFICERS

President, Ralph H. Houser, Roxbury Latin School, West Roxbury, Mass.
Vice-President, John P. Brennan, High School, Somerville, Mass.
Secretary, Carl W. Staples, High School, Chelsea, Mass.
Treasurer, Preston W. Smith, 208 Harvard St., Dorchester, Mass.

COMMITTEES

Executive
John C. Gray, Phillips Andover Academy, Andover, Mass.
Lawrence A. Howard, East Boston High School, East Boston, Mass.
Charles S. Lewis, Brighton High School, Brighton, Mass.

New Books and Magazine Literature
Richard Porter-Boyer, High School, Newtonville, Mass.
Floyd E. Somerville, High School, Newtonville, Mass.
George W. Seaburg, Hyde Park High School, Boston, Mass.

New Apparatus
Hollis D. Hatch, English High School, Boston, Mass.
Temple C. Patton, Worcester Academy, Worcester, Mass.

Dr. Andrew Longacre, Phillips Exeter Academy, Exeter, N. H.

College Entrance Syllabus
Fred R. Miller, Chairman, English High School, Boston, Mass.
Dr. Andrew Longacre, Phillips Exeter Academy, Exeter, N. H.
Albert Thorndike, Milton Academy, Milton, Mass.

BUSINESS MEETING

The following were elected active members:
Mr. Lawrence Harris, Boston Trade School, Roxbury, Mass.
Mr. Elbert P. Little, Phillips Exeter Academy, Exeter, N. H.
Mr. Edward B. Cooper, Brookline High School, Brookline, Mass.
Mr. Gorham B. Harper, Avon Old Farms, Avon Old Farms, Conn.

Attention was called to opportunities for teachers of physics, chemistry, and mathematics to exchange for a year with teachers in English schools. Anyone interested may obtain full details from Miss Elizabeth Patch, Secretary to the Education Committee, English Speaking Union of the United States, 33 Commonwealth Avenue, Boston, Massachusetts.

Announcement was made that the next meeting of the Association will be held at the Woods Hole Biological Laboratories, the probable date being May 13.

Members with automobiles who could furnish transportation for other members to and from Woods Hole, and members who would like such transportation, were requested to communicate with the secretary who will try to complete arrangements.

It was voted to accept the report of the College Entrance Syllabus Committee to be sent as a recommendation to the College Entrance Examination Board.

REPORT OF THE DELEGATE TO THE AMERICAN SCIENCE TEACHERS ASSOCIATION AND TO THE NATIONAL EDUCATION ASSOCIATION

MR. HOMER W. LESOURD

Mr. LeSourd reported that the American Science Teachers' Association with which our association is affiliated is growing in the number of affiliated organizations and in its influence. It represents the concerted effort of science teachers throughout the country to secure for science a larger place in education. It receives much free time from the larger radio broadcasting companies as well as an annual grant from the American Association for the Advancement of Science. The meeting held in Richmond just after Christmas proved to be of great interest. Two topics among the many discussed appealed to most of the delegates as being the very live issues of the year in science teaching—the increased use of the work-book and the rise of the "survey course" in senior high schools especially in the western part of the United States. At the annual luncheon of the association, Dr. Wesley C. Mitchell, president of the American Association for the Advancement of Science gave an excellent address.

Another nation-wide movement has recently been inaugurated in the middle west and this also deserves the thoughtful consideration and the cooperation of all teachers of science. Under the auspices of the science section of the National Education Association there is to be a study made of the 12 year science program and Mr. LeSourd has been asked to be a

member of the group of consultants who will furnish the general committee with information about the conditions of science teaching in our organization. He will also secure outlines of 12 year courses now in operation or contemplated as well as suggestions from members. It is hoped that this movement will receive the support of the association because of the obvious advantages that may result from having a substantial foundation on which to build the junior and senior high school science curriculum.

CONCEPTS OF THE ATOM

DR. FREDERICK E. WHITE, *Boston College*

Although Anaxagoras taught that the earlier Greeks were incorrect in their contention that matter was created and destroyed, and that, rather, these changes consisted of combinations or separations of invisible small particles of matter, it was Democritus who put forth a more definite statement of this view, postulating that the universe consists of empty space and an almost infinite number of indivisible and invisible particles, differing from each other only in form, position, and arrangement. This was twenty-three hundred years ago, but it was not until the early years of the nineteenth century that this hypothesis was confirmed by experiment. In the interim the atomic hypothesis was in disfavor due to its being discredited by Aristotle, but interest in it was shown by Galileo, Gassendi, Boyle, and Newton.

It was John Dalton who showed that chemical combinations between substances always take place in definite proportions. This fact can be accounted for by assuming that each elementary substance is composed of atoms. Thus Dalton converted a vague hypothesis into a definite scientific theory.

With this evidence of the existence of atoms, it was natural that interest should turn to the problem of the constitution of the different elements. Shortly after Dalton's work, Proût proposed the hypothesis that all elements are made up of the atoms of hydrogen as a primordial substance. The fact that the atomic weight of chlorine was found to be about 35.5 apparently doomed this hypothesis, but, as will be seen, it was revived later.

The next great contribution in this field was the statement of the laws of electrolysis by Michael Faraday, one of the greatest experimenters the world has seen. On the basis of the two laws, together with the postulate that each ion of hydrogen has the same mass and carries the same charge, the charge-mass ratio for hydrogen ions may be easily calculated, but the magnitude of either the charge or the mass may not be separately determined.

Sir J. J. Thomson, passing "Kathodenstrahlen" or cathode rays through magnetic and electrostatic fields was able to calculate the charge-mass ratio for a cathode particle. This ratio Thomson found to be 1,847 times that found by Faraday for hydrogen ions in electrolysis, this one being

independent of the kind of gas in the tube and of the metal used for the electrodes. These results could be interpreted to mean either that the charge on the cathode particle was much greater than that on a hydrogen ion, or that the mass of a cathode particle was much less than that of a hydrogen ion.

To resolve this ambiguity Thomson made use of the discovery that ions will act as nuclei for the condensation of drops of water in moist air. By observing the velocity of fall of a cloud formed in ionized air, Thomson was able to measure the charge, and in 1899, he performed the crucial experiment by measuring the charge by the cloud method and the charge-mass ratio by the magnetic deflection method, using the same particles for both experiments. Thus Thomson found the charge and hence indirectly the mass of a cathode particle—the particle which is now called an electron. The measurement of the charge has of course since been carried out much more accurately, notably by Millikan in his oil drop experiment.

But how about the magnitude of the charge on the hydrogen ion? The procedure here was to assume it to be the same as that for an electron, and then to calculate the number of atoms in a gram-atom of hydrogen. The results of similar calculations for other elements—making the same assumption—were identical with that for hydrogen. Furthermore the result agreed within experimental error with that found from a study of Brownian motion by Perrin in 1908. Thus the assumption has been considered to be a correct one.

It then follows immediately from Faraday's experiments that the mass of the hydrogen ion or atom is 1,847 times the mass of the electron.

This discovery of the electron together with the realization that it was one of the constituents of all atoms led to a general interest in the internal structure of the atom. Since it was observed that an atom is electrically neutral, the atom must have in addition to the negative charge due to the electrons, an equal positive charge. Furthermore, since the mass of an electron is such a small part of the mass of an atom, it follows that most of the mass of an atom must be associated with the positive charge.

Using these conclusions as a basis, Thomson proposed that an atom consisted of a sphere of positive electricity of constant density in which negative electrons arranged in rings are revolving. Some experiments of Lord Rutherford in which he observed the scattering of alpha particles which had passed through very thin gold foil led to the abandonment of this atom model, for the scattering angles were much greater than would be predicted according to this picture.

Thus Rutherford was led to propose his so-called nuclear atom model, according to which the atom was to consist of a concentrated positive charge surrounded by revolving electrons, the atom as a whole being electrically neutral.

A difficulty arose at once, however. A system of electrons rotating about a positive nucleus should, according to the classical electromagnetic

theory, continually radiate energy. Thus the electron would spiral into the nucleus.

To overcome this difficulty, Bohr, guided by some earlier work of Planck, proposed two revolutionary postulates, namely: the electrons may revolve only in certain orbits, and while remaining in any one orbit do not radiate; and, when an electron jumps from one orbit to another, it radiates energy, the frequency being given by the relation: freq. = $(W_2 - W_1)/h$, where W_1 and W_2 are the energies of the electron in its initial and final orbits respectively, and h is known as Planck's constant.

The Bohr theory was successful in predicting results which agreed with the experimental ones for many cases, but, as time went on, more and more arbitrary assumptions were required in order to keep theory and experiment in line.

Perhaps the next outstanding contribution in this field was by F. W. Aston, who, in 1919, using his mass spectrograph, showed that in cases such as chlorine where the atomic weight deviated from a whole number, the reason was that the chemical element consisted of atoms of different weights, present in definite proportions, the weights being themselves integers.

Thus, the trail leads back to Prout's hypothesis, only this time the building stones are two: the negative electron and the positive hydrogen nucleus or proton. Helium, for example, was considered to consist of a nucleus containing 4 protons and 2 electrons, surrounded by 2 extra-nuclear electrons. The 4 protons are necessary to take account of the atomic weight; the 2 electrons in the nucleus are required to give the nucleus the net positive charge needed to account for the deflection of helium nuclei by thin foil; and the 2 extra-nuclear electrons are necessary to make the atom electrically neutral. So it was felt that all atoms were made up of the constituents of the hydrogen atom.

As time went on, the dissatisfaction with the Bohr theory increased on the grounds that it needed too much patching to be able to agree with all the experimental results.

Schrödinger pointed out that just as in optics, ray methods are successful so long as the distances in question are large compared with the wave length of light, but wave methods must be used in the explanation of such small scale phenomena as diffraction, so the large-scale effects of an electron may be studied by particle dynamics but small scale effects must be treated by wave methods. In other words the electron acts under certain circumstances as if it had a wave nature. This point of view was confirmed in 1927 by Davisson and Germer who showed experimentally that a beam of electrons was scattered just like a beam of x-rays. It might be said of wave mechanics that the results are in better agreement with experiment than those of the Bohr theory, and, at the same time, that the assumptions made are more reasonable and fewer in number.

Among others, one of the things which the wave mechanics did was to make one give up the idea that an atom consisted of a nucleus with elec-

trons revolving around in definite orbits, and in its place, introduced the idea of probability, together with Heisenberg's Principle of Uncertainty or Indeterminacy, according to which there is no such thing as an exact knowledge of both the position and the velocity of a particle at a given time. This in turn raised the question of the validity of the Principle of Causality, the status of the idea of free will, and other questions of the same sort, starting a controversy which is still raging.

What might be called a period of comparative peace was shattered in 1930 when Böthe and Becker discovered a new particle having a mass approximately equal to that of the proton and being electrically neutral. Chadwick suggested it be called a neutron.

The process of Böthe and Becker might be indicated thus:

$$_4Be^9 + {_2He^4} \rightarrow {_0n^1} + {_6C^{12}}.$$

The superscripts are the atomic weights; the subscripts the atomic numbers. This relation suggested that the building stones of atoms should be increased to three: protons, electrons, and neutrons. On this picture the helium atom would consist of a nucleus containing two protons and two neutrons, surrounded by two extra-nuclear electrons. The atomic number is then defined as equal to the number of protons and the atomic or better the nuclear weight is equal to the sum of the weights of the protons and neutrons.

One of the most interesting occurrences in modern physics was the prediction on purely theoretical grounds by P. A. M. Dirac of a particle having a mass comparable with that of an electron and having a charge equal in magnitude and opposite in sign to that of an electron, this prediction being followed by the discovery of this particle, now called the positron, by Anderson, who was investigating cosmic rays by means of a cloud chamber.

So again the atom concept becomes more complicated. The helium nucleus might conceivably consist, for example, of 4 neutrons and 2 positrons. However, theory helps here by pointing out that such a nucleus would not possess the binding energy consistent with experimental results, i.e., the amount of energy binding the nuclear particles would not agree with the amount of energy found experimentally to be necessary to tear the particles apart.

Yet there are many perplexing questions involved. One is: Is a proton merely the combination of a neutron and a positron? Some experiments indicate that the answer should be yes. For example:

$$_{11}Na^{22} \rightarrow {_{10}Ne^{22}} + {_1e^0}.$$

Here we have a case of positron emission, and the equation states:

11 protons + 11 neutrons → 10 protons + 12 neutrons + 1 positron,

or, therefore:

1 proton → 1 neutron + 1 positron.

Another difficulty is that the law of conservation of energy does not seem to hold in many of these nuclear transformations. To get around this, Fermi suggested still another particle, a neutrino, a very light neutral particle. The experimental evidence for the existence of the neutrino is not conclusive as yet.

Before concluding there is one other subject which we should like to discuss. This is artificial radioactivity. With the powerful missiles now available by using, for example, a cyclotron, artificially radioactive substances are produced, i.e., substances which disintegrate in a manner similar to the natural radioactive substances such as radium. A few examples of this disintegration are:

$$_{29}Cu^{66} \rightarrow {}_{30}Zn^{66} + {}_{-1}e^{0}, \text{ an example of electron emission.}$$

$$_{31}Ga^{67} + {}_{-1}e^{0} \rightarrow {}_{30}Zn^{67}, \text{ an example of electron capture.}$$

The following disintegrations are also of interest, showing that all of a given sample does not react in the same manner:

$$\begin{cases} _{29}Cu^{64} \rightarrow {}_{30}Zn^{64} + {}_{-1}e^{0} \\ _{29}Cu^{64} \rightarrow {}_{28}Ni^{64} + {}_{1}e^{0} \end{cases}; \quad \begin{cases} _{30}Zn^{65} \rightarrow {}_{29}Cu^{65} + {}_{1}e^{0} \\ _{30}Zn^{65} + {}_{-1}e^{0} \rightarrow {}_{29}Cu^{65} \end{cases}; \quad \begin{cases} _{73}Ta^{180} \rightarrow {}_{74}W^{180} + {}_{-1}e^{0} \\ _{73}Ta^{180} + {}_{-1}e^{0} \rightarrow {}_{72}Hf^{180} \end{cases}.$$

What conclusions might be drawn from this brief survey of the evolution of the concept of the atom? There seem to be several general ones. One must have a feeling of respect toward those who have contributed to the progress which has been made. One must also readily see that the amount of work still to be done to ferret out the mysteries of the workings of atoms is tremendous. However, a third conclusion is a feeling that there has been a gradual evolution of ideas, a gradual progress, with theory and experiment going hand in hand. There should *not* be a feeling that what is learned today will probably be denied tomorrow. Rather in each period, the theory is adequate to explain the precision of experimental knowledge of that period. As experiments are performed more precisely, theory develops to take care of this, or, vice versa, as theory makes predictions, more careful experiments are performed to test the predictions.

Finally as the mysteries of nature are slowly unravelled, one must pay more and more tribute to the Creator of nature, for certainly, to change the figure, the unfolding of the wonders of nature must lead to a greater appreciation of the Author of nature.

THE ACOUSTICS OF AUDITORIUMS AND CLASSROOMS

RICHARD L. BROWN

For convenience the science of sound may be divided into three important branches—speech and hearing, sound transmission and reproduction, and architectural acoustics. The present discussion will be confined to the last division, and to a review of some of the significant properties of rooms which lead to good hearing. Good hearing is particularly

important in classrooms, where the strain of difficult listening conditions may prove to be a serious handicap to students.

We may say that architectural acoustics became a science in 1895, when W. C. Sabine was assigned by Harvard University to propose changes in the newly completed Fogg Art Museum lecture hall for the correction of its acoustical difficulties. Little was known at that time about what factors determined the acoustical properties of rooms; in fact, little was known about just what acoustical properties were desirable. Often an auditorium turned out to be unsatisfactory, even if it was modelled closely after a "good" auditorium. Such had been the case with the Museum lecture hall. We know now that the apparent unpredictability of acoustical properties was due to failure to duplicate the controlling factors of the model. While the shape of a room might be faithfully copied, the volume was altered; or perhaps the model had plaster-on-wood walls and the copy was of hard plaster-on-tile. These factors, then regarded as details, are actually the primary factors in determining the acoustical qualities of a room. Shape is of secondary importance.

Not much was known about how to correct acoustically deficient buildings. The usual difficulty was excessive reverberation, which results in the blurring of speech, the running together of syllables and words with loss of clarity and intelligibility. In some cases literally miles of wires were strung across "noisy" rooms to break up and absorb the excessive sound. This cure always failed to work, and at the time no other was known.

In spite of the apparent complexity of his problem, Sabine early in his investigation analyzed the acoustical requirements of a room. He stated:[1] "In order that the hearing may be good in any auditorium, it is necessary that the sound should be sufficiently loud; that the simultaneous components of a complex sound should maintain their proper relative intensities; that the successive sounds in rapidly moving articulation, either of speech or music, should be clear and distinct, free from each other and from extraneous noises. These three are the necessary, as they are the entirely sufficient, conditions for good hearing."

Anyone who has tried to call out to another person across an open field realizes how rapidly the loudness and intensity of a sound decrease with distance away from the source. In a closed room or auditorium, however, much of the sound which out-of-doors would be completely lost is conserved by reflection from the walls. A sound wave travelling away from the speaker may be reflected, losing part of its energy upon reflection, from a wall or ceiling toward the listeners. In fact, the wave may suffer many, many reflections before it is heard or becomes lost. These reflected waves contribute very materially toward raising the sound level in the auditorium and equalizing the difference in loudness between the front rows of the audience and the back.

But at the same time these reflected waves introduce distortion in the

[1] *Collected Papers on Acoustics*, Harvard University Press, 1927.

sound. We are all familiar with the reflection effects in a stretched rope or string, fastened at one end and wiggled at the other. By properly timing the "wiggles" we can get very large amplitudes of motion at some parts of the rope and very small amplitudes at others, the phenomenon called standing waves. This simple one dimensional analogy suggests the far more complicated interference and resonance effects one gets from "wiggling" or driving with a sound source the air in a room, for the latter is a three dimensional medium. Waves may be reflected back and forth between any pair of opposite walls, between four walls, or between all six walls.

The existence of standing wave patterns in a room is made clear by a simple experiment. If a continuous note, such as from a high-pitched organ pipe or whistle, is sounded, one can by listening with one ear and moving his head about slowly pick out regions of high intensity and sharply bounded minima of intensity. It is easy with this example in mind to imagine the complexity of the wave pattern and the possible distortion of a musical chord in a "live" room with good reflection at the walls. Some notes or frequencies may be absorbed more rapidly than others, and at the point where one is listening a maximum of intensity for one frequency may coincide with a minimum of another, so that the proper balance between individual low, medium, and high notes is completely obscured.

So far we have considered only distortion of sound in space; we must consider also distortion in time. The sound of the word *two*, for example, is short and sharp. If the pulse of waves for this short, transient sound is reflected back and forth around the room for several seconds before it becomes lost, we will be still hearing the *two* while we are trying to listen to sounds uttered several syllables or even several words later. The resulting confusion, the piling up of sounds with loss of distinctness and intelligibility, is called reverberation. It is to be distinguished from echoes, which are discreet, clear reflections, as from a distant building or hill.

It is clear from just a qualitative discussion that in designing a room we must compromise between hard, reflecting walls which absorb little sound and help in building up loudness, and porous, absorbing walls which prevent resonance distortion and disturbing reverberation. Fortunately this compromise is, in general, not difficult to make. The job of an acoustical engineer is that of finding how much absorbing material a room should have, and where it should be placed, if the latter proves to be important.

While any attempt to study rigorously the building up of sound in a room would lead us far afield, a very much simplified mathematical analysis is sufficiently accurate for practical purposes. The building up of sound from a continuous source is indicated in figure one. If, let us say, an organ pipe is started at time A the sound intensity in the room builds up rapidly at first, and then approaches a constant value, at point B. If the source is later stopped, at point C, the sound dies away, again rapidly at first, and then slowly approaching zero intensity. The time for a sound to decay from its intensity when the source is stopped, point C,

to one millionth of this value, point D, is defined as the reverberation time of the room. In technical terms the sound level has fallen 60 decibels, for the difference in intensity levels expressed in decibels is equal to ten times the common logarithm of the ratio of the initial and final intensities. Actually the reverberation time varies with frequency, but an average, easily measured value is surprisingly satisfactory for practical purposes.

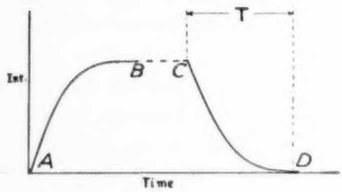


FIG. 1

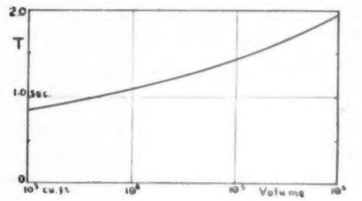


FIG. 2

Beginning with the assumption that when a sound wave strikes a wall surface a fraction of it, α, is absorbed and the remainder, $(1-\alpha)$, is reflected, and by considering the average distance and time between reflections, an expression for the reverberation time, T, can be derived. It is

$$T = .05\,\frac{V}{a}, \qquad a(=\alpha_1 A_1 + \alpha_2 A_2 + \cdots). \tag{1}$$

Where V is the volume of the room in cubic feet and a is the "total absorption" of the room. It is computed by multiplying the area of each surface material in the room in square feet by its proper "absorption coefficient" α_n. An open window is considered a perfect absorber, and its α is taken as unity. The absorption coefficients for the important frequency range vary from about 0.02 for glass or stone to about 0.4–0.7 for heavy drapes, perforated celotex, or other good absorbers. Reliable tables of absorption coefficients are available in standard texts on acoustics and from manufacturers of acoustical materials. Knowing the dimensions of a room, the areas of its surface materials and their absorption coefficients, one can with equation one predict the reverberation time with remarkable accuracy. If it turns out to be too large, it can be readily reduced by the addition of absorbing material, usually on the ceiling or back walls. If the room contains many chairs or is to seat many people, allowance must be made for their absorption. The correction to be added to the computed value of a is about 4.5 units per person and 1–2 units per upholstered chair.

The optimum value of the reverberation time, particularly for music, is rather arbitrary. Musicians often prefer the added volume and richness which come with much reverberation. For speech, however, articulation tests such as are used by engineers in testing telephone performance give a more definite measure of the best value. T is generally preferred longer in large rooms than in small. That is, in large rooms some sacrifice in

clarity and articulation is made for an increase in loudness. Figure two gives a plot of optimum reverberation time as a function of room volume averaged from the results of several workers.

The present tendency for large auditoriums is to design for a somewhat shorter reverberation time, making up for the loss in loudness by the use of sound reinforcement or public address equipment. Care must be exercised, however, not to raise the intensity too much, for change in frequency response of the human ear with loudness makes over-loud speech or music sound distorted. Most of us are too familiar with the unnaturalness of listening to a singer who, either on the stage or on the screen, is to our eyes some distance away, but to our ears seems from the blaring of her voice far too close for comfort. This change in quality with volume is most noticeable when we try to recognize voices of our friends recorded on instantaneous playback records. Sound technicians and the public are just beginning to realize the importance of proper volume levels, and that quantity of reproduction and quality of reproduction do not always go hand in hand.

The steady state intensity of sound in a room is simply related to the power of the source, if we assume that the intensity is uniform throughout the room and that all absorption takes place at the walls. The relation, valid for high frequencies and accurate enough for practical work turns out to be

$$I=\frac{P}{1000a} \tag{2}$$

where P is the power of the source in microwatts, I the intensity of the sound in microwatts per square centimeter, and a the total absorption in square feet as defined for equation one. The average output power of speech varies from 10 microwatts for ordinary conversation to 1000 microwatts for a loud speaking voice. A good intensity level for classrooms might be 10^{-3} microwatts per square centimeter, which corresponds to 70 decibels on the conventional zero decibel reference level near the threshold of audibility.

As we have pointed out, the amplitudes of motion of a "wiggled" rope depend upon the period of the driving force. Frequencies of greatest response are called natural frequencies. The lowest is the fundamental or first harmonic, for which the rope is just half a wavelength long, and the other natural frequencies are integral multiples of the fundamental frequency, called higher harmonics. A room similarly has many natural frequencies, for which it responds best to a sound source. The lowest three come, in general, when the room is half a wavelength of sound in length, in width, or in height. The complete picture is very complicated, for in addition to these three frequencies and all their harmonics, we may excite natural frequencies involving reflections from more than two walls. If we measure at random points the intensity of sound due to a source of constant output but of variable frequency, we find sharp maxima of intensity at each resonance frequency of the room. The height and sharpness of

these resonance peaks depend upon the amount. and somewhat upon the location, of the absorbing material in the room. At high enough frequencies these peaks come close together, overlapping and giving a fairly smooth response curve; but at low frequencies they are far enough apart to produce serious irregularities in the room's response. A useful expression for the minimum frequency for which the resonance response is reasonably constant, f_{min}, is

$$f_{min} = \frac{10^4}{\sqrt{80a}} \cdot \tag{3}$$

This equation, while necessarily very approximate and arbitrary, is nevertheless useful. A large auditorium may respond smoothly down to 10–15 cycles per second; a small room to 250 cycles. Uniform response at low frequencies is more important for music than for speech. A very small, hard walled room cannot be expected to do a good job for phonograph reproduction, regardless of how good a phonograph is used in it.

We have seen that the three necessary and sufficient conditions for good hearing in a room are not independent, since all three involve the total absorption in the room, and that in general there must be some compromise between loudness, fidelity, and articulation. But ordinarily if the reverberation time alone is properly adjusted any room will be acoustically satisfactory. Further analysis and treatment may be required for auditoriums having large curved wall surfaces which tend to focus sound and occasionally cause disturbing multiple echoes. And special consideration may have to be given to sources of noise, such as motors or machinery within the room, or to extraneous noise transmitted through the walls from external sources. The general procedure in these cases is to prevent insofar as possible vibration at the source; to minimize its conduction to large radiating surfaces, as by mounting motors and pumps on sponge rubber bases; and to absorb persistent vibrations by the use of damping material.

An easily assembled and portable apparatus, excellent as a laboratory experiment, for measuring reverberation times consists of an automobile horn emitting a musical tone, a battery for power, and a stop-watch. By sounding the horn in a quiet room for a few seconds, that is until the steady state is reached, and timing the period during which the sound remains audible after turning off the horn, with ten or more readings repeated in various parts of the room, one can get a good average value for the reverberation time. A simpler, often satisfactory, method is to "calibrate" oneself in a room of known reverberation time, using for a source a single hand-clap, and noting how long its sound remains audible. If it is two-thirds of the known time, the "calibration factor" of two-thirds will, with a bit of practice, hold for the same person in other rooms.

Having measured the reverberation time of a room by these methods or by more precise laboratory techniques, and knowing what it should be, the problem of the acoustical engineer then usually reduces to choosing a physically and economically suitable absorbing material, and using a

little judgment as to how much should be added to the room and where it should be placed, preferably on non-opposite room faces, and toward the back.

Present research in architectural acoustics is dealing with more rigorous expressions for the absorption at a reflecting surface to extend the very average α, and working toward a better understanding of the resonance response of rooms and their reverberation times as functions of frequency. Much of the experimental work is being done in small rooms, and scale models not more than a few feet in the longest dimension.

Providing the proper conditions for good hearing is not a difficult problem. Although often neglected, acoustical requirements should be considered an integral part in the design of new buildings and in the reconditioning of old buildings, particularly school auditoriums and classrooms. It is no more fair to students to make them work under conditions of poor hearing than under conditions of poor lighting. The day will come, if it is not at hand, when administrators will realize the value of good hearing as an excellent investment in education.

SOME REFLECTIONS ON THE TEACHING OF PHYSICS

Professor Robert B. Lindsay
Brown University

Once upon a time in a certain far away country there lived a king who was much concerned over the ignorance of his subjects. So he summoned the wise men of his kingdom and said to them: "Let the people be taught, for they are very ignorant!" Thereupon the leader among the wise men spoke: "And what, O King, would you have them taught?" "That, my wise counsellors, should be well known to you," replied the king; "teach them that which is good for them."

So the wise men retired to meditate on the king's command. After an interval they returned to the council chamber. "Well," said the king, "what have been the results of your teaching; are the people no longer ignorant?" "Alas, O King, we have as yet taught them nothing." "Why?" "Because we can not agree what is good to teach. Some among us are of the opinion that the people should be taught simply to be more skillful in the use of their tools. Others among us believe rather that the brightest of them should learn the causes of things—the mysteries of Nature. Still others fear lest the people learn too much and become wise even as we are. What shall we do, O King, since we cannot agree on what to teach?" "Regard not the mysteries of Nature," replied the monarch. "Teach the people to observe things as they really are and how they really go."

So the wise men went away a second time and after another interval reported to the king, who asked them what success they had had. "Alas, O King, we have even now not yet taught." "What," exclaimed the king,

"did I not tell you what to teach?" "Yes, O King, but we can not agree *how* to teach it." "Oh, bother," cried out His Majesty, "this will never do!" So he ordered the wise men's heads chopped off, turned the palace into a school and went into progressive education on his own hook.

It would indeed be interesting to follow the results of his experiment. But we shall forego this speculation in order to ponder a little on the possible application of this parable to the teaching of physics. It suggests, of course, that there are two fundamental questions connected with this problem: (1) What shall we try to teach about physics, and (2) how shall we teach it? Obviously, however, before we can attack these questions we must reach an agreement as to what physics really is. This is not so simple as might appear at first sight. What some people think of as physics looks to others suspiciously like engineering, while at the other extreme much of the stuff which appears in physical journals looks to some more like metaphysics than physics. One must be pretty broadminded to include it all and clearly no narrow definition is possible. I think it is generally agreed, however, that all physicists claim they are trying to describe a portion of human experience by means of a method which, having gone through a relatively long course of evolution, is now admitted to be fairly successful. It seems only reasonable to ask that those who aspire to teach physics should form in their own minds a clear conception of what this method is. It is a method which does not content itself simply with a cataloging of sense perceptions in terms of the language of ordinary life, though this would indeed be a description and probably the only kind of description which in the long run has meaning for the vast majority of people. But the physicist from the days of Galileo onward has not been satisfied with it. He feels that he can really understand what goes on only if he is able to *relate* all his various observations, whether they are passive or the result of very intricate laboratory operations. And the establishment of such relations, called *laws of physics*, has proved possible in an economical sense only by the introduction of abstract but carefully defined concepts. Maybe life would be a lot simpler if we were content to note, for example, that when one end of the poker is put in the fire, the other end gets hot. In the same way the psychologists might be content to observe that when one end of a man is stepped on the other end shouts! It is a far cry from the simple thermal observation of the poker, however, to the abstract concepts of energy, temperature, heat conductivity and the other ideas that go to make up thermodynamics. This is not the place to embark on an investigation as to *why* physicists introduce abstract concepts and call that process a better understanding of nature: it is really a psychological problem. We had better leave the question "why" out of physics, anyway, and concentrate on the question "how."

Now physics is not simply a collection of laws. The very introduction of the concepts in terms of which physical laws are expressed stimulates powerfully a form of mental activity of which mankind has long been

fond, namely, *speculation* or theorizing. The contribution of the imagination to physics is the development of physical theories, the last stage in the description of nature. We must not think that the process is essentially a new one: the ancient Greek philosophers speculated freely about nature; they had their theories and very interesting ones they were, even if we are not profoundly impressed by their worth today. However, the fundamental logical notion of a theory has not changed so much as the way in which theories are used. The theory of mechanics, which next to geometry is the oldest of physical theories recognized as valuable today and possibly for that reason is hardly ever thought of by most people as a theory at all, is logically of the same structure as the theory of quantum mechanics which is as yet so unfamiliar to people in general that it is apt to be considered quite hopelessly theoretical and un-understandable.

I mentioned geometry just now as a physical theory. We usually do not recognize it as such because it is taught as mathematics. Nevertheless it began as physics and its logical structure is the same as that of all physical theories. You will recall that it begins with certain primitive undefined spatial ideas like point, line, etc., which are assumed to be intuitively known and which can be operationally approximated with ordinary solid rods. With these as a basis it defines certain more elaborate constructs. Finally it lays down a set of so-called axioms and postulates which are the "rules of the game," the assumptions which are adopted either because they *seem* self-evident or because they are suggested by actual experience with measuring instruments. These assumptions or hypotheses, for that is their logical character, are the fundamental *principles* of geometrical theory. The development of the science then consists in the logical deduction from the hypotheses: these are called the theorems, but we might equally well call them the *laws* of the science of geometry. They have indeed exactly the same character as physical laws as precise descriptions of experience. We can verify by laboratory measurement all the theorems of geometry, using apparatus which conforms to the fundamental definitions and principles, and this I believe should constitute a vital part of all successful teaching of geometry.

All physical theories have the same logical structure of: (1) basic, primitive, intuitive notions (e.g., those of space and time in mechanics), (2) well defined constructs (e.g., velocity, acceleration, mass, force in mechanics), (3) hypotheses (e.g., the fundamental principle $F=ma$) and logically deduced laws (e.g., the falling body equation $s=\frac{1}{2}gt^2$). If the theory is successful, the logically deduced laws must be experimentally verified, i.e., they must be identical with the experimentally discovered rules which are descriptive of the phenomena being studied. Often, of course, we hope the theory will predict laws that have not yet been observed. Their successful experimental verification strengthens our confidence in the validity of the theory but we must never forget its essentially hypothetical nature.

By this time you are probably ready to object that all I have said may be well enough but what possible connection does it have with teaching? Does it mean that we are to teach youngsters the philosophy back of the method of physics? I must hasten to reassure you that nothing could be farther from my mind! What I *do* want to emphasize is my conviction that every one who aspires to teach physics on *any* level should have a thorough understanding of what this method is. In no other way does it seem possible to reach a rational solution of the pedagogical problems involved in the teaching of physics.

Well, then, to come back to the beginning, what *shall* we teach about physics? It is a troublesome question and on reflecting over it we are inclined to sympathize with the king's wise men in the parable. We, too, have colleagues and have had occasion to marvel at the diversity of opinion on this subject. But after all can we not perhaps extract some value from the old king's advice: teach people to observe things as they really are? It is interesting to note that all the great physics teachers of the past, men like Maxwell, Faraday and Tyndall, who though known principally as research investigators nevertheless paid close attention to teaching problems, all put first in their criteria for successful teaching the development of the power of accurate observation of phenomena. To my mind this is ultimately far more important than the specific topics taken up with the class. There will always be a healthy diversity of opinion on how *much* heat, how *much* mechanics, how *much* electricity and magnetism, etc., should go into making a well-rounded course in general physics. Arguments along this line, however, are too apt to lay emphasis on how much stuff one can cram into a youngster's mind in a year's time. But this is far from being the vital problem. Rather we ought to pick our topics in such a way as to assure the maximum cultivation of the power of precise observation. One way to achieve this is to place emphasis on those parts of the subject which involve maximum correlation of different ideas. But above all it is desirable to encourage the student to observe for himself and not be contented merely with getting his information at second hand.

All this suggests that probably *what* we teach about physics is not so important as *how* we teach it.

Some one once defined education as a book and a big stick. This is certainly what it used to be: the boy was supposed to apply himself to his book and the stick was applied to the boy. Modern American educational practice has abandoned the stick but we still have the book! In fact we are deluged with them. This does not imply that textbooks are not useful things—they are indeed indispensable. However they defeat their purpose in the sciences if used too slavishly. Physics teachers will do well to adopt as their own the motto of a famous naturalist: "Study Nature, not books!" That teaching of physics will in the long run be most successful, I am convinced, in which the student is brought face to face in his own

experience with all the principal phenomena which are studied. As much as possible should be done by the student himself with simple apparatus. For the rest the instructor should provide adequate demonstrations. I see no reason why this should not be as true for the high school course as for the elementary college course. In this connection I can strongly recommend the reading or re-reading of the inaugural lecture delivered by Clerk Maxwell in October, 1871 on the assumption of his duties as the first Cavendish Professor in the University of Cambridge. It might be supposed that the introductory lecture by the man who was even then recognized as one of the leading theoretical physicists of his time and who is today regarded as the greatest theoretical physicist of the whole 19th century, would have been devoted to the latest developments of his mathematical researches. Actually Maxwell dedicated his discourse almost entirely to the teaching of physics. His words are worthy of close attention even today, for all our boasted modern gadgets. They should cause us to reflect whether we are giving the best and getting the most out of our lecture demonstrations and laboratory experiments. After pointing out the fundamental aim of a demonstration experiment, Maxwell makes the following statement: "The simpler the materials of an illustrative experiment, and the more familiar they are to the student, the more thoroughly is he likely to acquire the idea which it is meant to illustrate. The educational value of such experiments is often inversely proportional to the complexity of the apparatus. The student who uses home-made apparatus, which is always going wrong, often learns more than one who has the use of carefully adjusted instruments, to which he is apt to trust, and which he dares not take to pieces." My own teaching experience has emphatically confirmed the conviction expressed in this quotation. I realize that objections can be raised against this point of view and in favor of elaborate demonstrations with complicated modern equipment. These are defended on various grounds such as, for example, that striking experiments which can be performed with involved apparatus are necessary to stimulate the student's interest and that in any case he ought to see the advances which modern technique has made possible. Both viewpoints are to a certain extent plausible. Students like vaudeville shows and so do most of the rest of us occasionally. But we ought not to delude either ourselves or our students into thinking that when the instructor presses a button and something striking happens, physics is necessarily being learned. In any case it is much more sensible to consider such experiments as luxuries to be enjoyed after the basic ideas have been made plain with the most elementary equipment.

I have so far spoken of lecture demonstrations. More important really are the experiments which the student performs for himself. It is my conviction that no general elementary physics course either in secondary school or college should be taught without laboratory. Where the laboratory work is performed listlessly one can be sure that something is wrong

with the physics teaching. Unfortunately, what ought to provide a thrill of satisfaction in discovering something for oneself too often degenerates into a mere perfunctory following of directions and a devious guess for the *right* answer. It is hard to know just what the remedy should be. We ought to realize, however, that it is primarily in the laboratory that the student's individuality comes most prominently to the fore. This places a premium on individual attention, which often, alas, in our day of boasted efficiency is considered uneconomical. I have been led to think that it is not at all necessary that all students should perform the same set of experiments. Many students will get far more out of a large number of qualitative experiments than from a small number of more elaborate quantitative studies. In fact, we ought to stress more emphatically than I suspect is usually the case the qualitative experiment which gives the student considerable freedom to arrange his own conditions and find out for himself what happens, irrespective of "what the book says." There is, to be sure, a powerful objection to this course: time is short and the number of students large. But this difficulty is predicated on a *rigid* system according to which a definite, previously assigned task is scheduled for each laboratory period. Too often, I fear, the instructor's only interest is to see the student "get through" this assigned task, whether he understands what he is doing or not. There ought to be some way to relieve the inflexibility of such a system, at the same time assuring that the student will be kept busy. I feel very strongly at any rate that no quantitative experiment should be undertaken in any field until the basic qualitative phenomena have been observed at first hand. Moreover, even in the *Measurements* performed in the elementary course the emphasis should be on simplicity of set-up, so that the student will not fail to see the woods for the trees. If the laboratory has been successful the student of average grade or better will want to try things for himself at home. It is up to the clever instructor to suggest experiments which can be done with even simpler apparatus than that available in the laboratory. The number of these is legion.

From a consideration of the physical laboratory and its importance it is perhaps appropriate to pass to the mention of a type of physics teaching which claims to do without laboratory work altogether. I mean the so-called survey course, which has recently become the rage in certain collegiate circles. I do not know whether the craze has penetrated into the secondary field. It would not surprise me to find that it has. In any case this occasion provides an opportunity of recording some of my own reflections about it. The words I have just used are not meant to convey the impression that I am irrevocably prejudiced against the idea for it certainly merits impartial examination. As commonly understood the physics survey course is an attempt to supply college freshmen in a fraction of a year with an orientation in the whole field of physics. This is done wholly by the lecture method but usually with required outside supplementary reading. Such a course is supposed to be particularly valuable for the non-

science major. Now just what can the survey course be reasonably expected to accomplish? Is it sensible to suppose that it will give the mythical average student a real understanding of the method of physics or of the fundamental concepts which underlie physical theories? It seems to me that to expect this is to commit a psychological fallacy, namely that of believing that you can make an abstract idea perfectly clear to a youngster merely by calling his attention to it as you would to a date in history. No one learns physics merely by having his attention called to it. Abstract concepts like force, mass and energy mean essentially nothing but words to the student until he has seen them illustrated over and over again in numerous experiments, has himself performed experiments involving them, and has solved a large number of illustrative problems in which they enter. This means steady application, it means drill, it means patience and perseverance on the part of both teacher and student, it means considerable self-discipline. All these are ideas inevitably foreign to the survey type of course. I am aware that some people feel you can get the orientation stuff across painlessly, as has been said, in the form of "learning put lightly, like powder in jam," with the liberal use of analogies. This is indeed the method of popular science and one must admit that it entertains and amuses. But honest inquiry reveals that it misleads far more than it instructs.

Well, then, is there nothing which a survey course *can* accomplish? In my opinion, all it can and should try to do, is to present actual physical phenomena to the student in the form of simple demonstrations and let the matter of concepts and theories alone. Above all it should try to encourage the student to do his own experimenting. In this way he may actually get an *operational* view of physics which is founded at any rate on fact and not merely on pretty allegories whose only purpose, it appears, is to enable the possessor to charm in polite conversation.

Let me take leave of the survey idea at this point. It has been, indeed, an interpolation in the main current of my reflections, which are intended to apply as much to the secondary school physics teaching problem as to that of the college elementary course. Inevitably the embarrassing question sooner or later arises: what shall be the place of mathematics in elementary physics teaching? Now mathematics enters physics in two ways: first, through the fact that physical measurements are quantitative and hence involve numbers, and second, through the fact that abstract symbolism has proved to be the most economical and powerful language for the expression of physical laws and theories. The use of mathematics in physics has been loudly proclaimed to be the chief source of students' troubles and it is often alleged that there are some people are who constitutionally unable to follow logical reasoning when it is cast in the form of abstract symbolism. While I believe this to be an extreme statement, it remains true that persons differ widely in the vividness with which abstract reasoning appeals to them. Nevertheless, since mathematics *is* the natural language of physics it is futile to dodge it. Rather the physics teacher

has a splendid opportunity to make the student realize that the mathematics which has been formally drilled into him as a collection of rules and whose use often appears a mystery save as a sort of mental discipline, actually has a vital part to play in the understanding of Nature. When the student finds he can actually use mathematics to get practical results he will have a healthier regard for it. In this way the physics teacher can cooperate with the mathematics teacher and help to break down barriers which all too often separate departments of study even in secondary schools. At the same time it is vitally important that in using algebraic formulas, for example, the student shall attach precise physical meaning to every symbol. We all know the student who is stalled in the solution of a problem because he cannot find the formula containing precisely the right collection of symbols to match the given data. Such use of mathematics is absurd and pernicious. Mathematics is not a *substitute* for thinking: it is an *aid* to rigorous thinking.

It is my experience that when the college student begins to use his mathematics in elementary physics he is weakest not in algebra and geometry but rather in arithmetic. Here, I think, the secondary physics teacher can perform a real service by insisting that students shall develop practicable methods for solving numerical problems without covering the whole page with figures and then winding up with the wrong decimal point. After all it is the decimal point which *is* the important thing in answer to the physics problem. If the student could be made to express all numbers in terms of a simple number with one digit to the left of the decimal point multiplied by an appropriate positive or negative power of ten, his arithmetical troubles could be reduced considerably. He should then be able to estimate the order of magnitude of the numerical result without further calculation, assuming, of course, that he remembers the multiplication table up to 10 times 10. Perhaps in these days in which memory has been discarded as useless intellectual equipment, this is assuming too much! The scheme I suggest will also greatly facilitate the student's learning the use of the slide rule. Moreover it ties in effectively with the very desirable emphasis on significant figures in physical problems.

And so I come to the end of my reflections, for the time being, at any rate. I realize keenly how many things I have not touched upon which many will deem more important than the things I *have* mentioned. For example, I have said nothing about the valuable use which may be made of historical references in the elementary physics course. About this I daresay there is no disagreement. On the other hand I have refrained from discussing the very controversial topic of the "interest" versus the "mental discipline" motivation in science teaching, or in all education for that matter. I have used the word "controversial," though as a matter of fact, some educators have told me that there is no controversy any more—mental discipline is dead: you must teach the student what interests him, particularly what he expects to "use" in his subsequent career, for nothing

else will mean anything to him. It may be so, but personally I do not believe it. And one of the principal reasons why I do not believe it is that it comes dangerously close to denying what I consider to be a cardinal principle of success in all human activity, namely that by and large you never succeed in doing anything worth while in this world unless you *work* for it, unless you concentrate all your mental equipment on it.

Of course, physics is hard work and so is physics teaching! It cannot be successful except as a cooperative effort on the part of both teacher and student. The former owes it to the latter to put all his vitality into his work and to demonstrate the same enthusiastic interest in every phase of his subject which he would like to see in his student. This is doubtless a counsel of perfection. Some of us may well feel we work too hard as it is without achieving the desired results, a feeling which the WPA under our eyes has not tended to diminish. When you have put in a hard day's work and are feeling particularly blue over the lack of obvious results, you may find interesting relaxation and possibly a slight buoyancy of spirit in reading about a certain great teacher of long ago, who faced the same teaching problems which we face today and met them with vigor and determination. His name is probably not unknown to you, though he lived and taught some 200 years ago. He was Colin Maclaurin, Professor of Mathematics at the University of Edinburgh from 1725 to his death in 1746. Most of you will recall the famous series expansion to which his name will ever be attached. Poor old Maclaurin! Listen to his teaching schedule as presented by his biographer, from whom I quote:

"Upwards of a hundred young gentlemen attended his lectures every year; who being of different standings and proficiency, he was obliged to divide them into four or five classes in each of which he employed a full hour every day, from the first of November to the first of June.

"In the first or lowest class (sometimes divided into two) he taught the first six books of Euclid's Elements, plain (sic) trigonometry, practical geometry, the elements of fortification and an introduction to algebra. The second class studied algebra, the 11th and 12th books of Euclid, spherical trigonometry, conic sections, and the general principles of astronomy. The third class went on in astronomy and perspective, read a part of Sir Isaac Newton's *Principia*, and had a course of experiments for illustrating them, performed and explained to them. He afterwards read and demonstrated the elements of fluxions: those in the 4th class read a system of fluxions, the doctrine of chances, and the rest of Newton's *Principia*."

One is inclined to wonder how he found time for his book writing and other activities!

Maclaurin's biographer goes on to say in the quaint style of the middle 18th century:

"All Mr. Maclaurin's lectures on these different subjects were given with such perspicuity of method and language, that his demonstrations seldom stood in need of repetition: such, however, was his anxiety for the im-

provement of his scholars, that if at any time they seemed not fully to comprehend his meaning, or if, upon examining them, he found they could not readily demonstrate the propositions which he had proved, he was apt rather to suspect his own expressions to have been obscure, than their want of genius or attention; and therefore he would resume the demonstration in some other method, to try if, by exposing it in a different light, he could give them a better view of it."

Perhaps all of us engaged in this business of teaching physical science can profit somewhat by the example of Colin Maclaurin.

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON

State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

NOTE. Persons sending in solutions and submitting problems for solution should observe the following instructions.

1. Drawings in India ink should be on a separate page from the solutions.

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

LATE SOLUTIONS

1590. *R. B. Deal and Mary Rinehart, students, University of Oklahoma.*

1586, 87, 88, 1590, 91. *Sidney Cabin, Brooklyn, Kenneth P. Kidd, Gainesville, Gainesville, Fla.*

1591. *Hugo Brandt, Chicago.*

1592. *Proposed by Cecil B. Read, University of Wichita.*

Show that $(n!)^2 > n^n$ for $n > 2$.

First Solution by Edward C. Varnum, Clyde, Ohio

The left member of the inequality may be expanded and rearranged in pairs as follows:

$$1\cdot n \quad 2(n-1) \quad 3(n-2) \cdots r(n-r+1) \cdots 2(n-1) \quad 1\cdot n.$$

This consists of n products, the first and last of which both equal n.

Consider the $n-2$ products which we shall now assume to exist. Each product is of the form $(n-r+1)r$ in which $n>r>1$. Now, as long as $(n-r)$ and r are both greater than unity:

$$(n-r)r>n-r.$$

Adding r to both members of the inequality:

$$(n-r)r+r>n, \quad \text{or} \quad (n-r+1)r>n.$$

Thus we see that each of the $n-2$ products is greater than n itself, and therefore if n is greater than 2 the expansion of the left member is greater than the product of n taken n times.

Second Solution by James K. Hitt, University of Wichita

The proposition can be verified for $n=3, 4, 5$, etc. Using mathematical induction, assume $(n!)^2>n^n$.

For $n>2$,

$$(n+1)>e>(1+1/n)^n=\left(\frac{n+1}{n}\right)^n$$

Multiplying by $n^n(n+1)$, we obtain

$$(n+1)^2n^n>(n+1)^{n+1}.$$

But

$$(n+1)^2(n!)^2>(n+1)^2n^n.$$

Therefore

$$(n+1)^2(n!)^2=[(n+1)!]^2>(n+1)^{n+1}.$$

Solutions were also offered by James A. Lemon, Eaton, Ohio, O. L. Dunn, Vincennes, Ind., John Wagner, Lewis Institute, Chicago, Ill., M. Kirk, West Chester, Pa., Hugo Brandt, Chicago, Ill., Walter R. Warne, Minneapolis, Minn., Charles W. Trigg, Los Angeles City College, C. C. McCauley, New York, Garland D. Kyle, Knoxville, Tenn., and also by the Proposer.

1593. *Proposed by John N. Meighan, Harpers Ferry, W. Va.*

Given a triangle ABC, with the altitude KC fixed in position and magnitude. What is the locus of points which divides one of the sides through C harmonically?

Solution by Charles W. Trigg, Los Angeles City College

It is implied that A and B are variable points along the line AKB which is perpendicular to KC. The sides of an angle and its internal and external bisectors form a harmonic pencil. Hence the bisectors of angles AKC and CKB constitute the required locus. In fact, the magnitude of KC need not be fixed.

Solutions were also offered by Walter R. Warne, Minneapolis and also by the proposer.

1594. *Proposed by Cecil Read, University of Wichita.*

Find, without the use of calculus, the minimum value of

$$\sqrt{a^2\cos^2\theta+b^2\sin^2\theta}+\sqrt{a^2\sin^2\theta+b^2\cos^2\theta}.$$

Solution by M. Kirk, West Chester, Pa.

Let

$$P=\sqrt{a^2\cos^2\theta+b^2\sin^2\theta}+\sqrt{a^2\sin^2\theta+b^2\cos^2\theta}$$

Now P reduces to

$$\sqrt{\frac{a^2+b^2}{2}+\frac{a^2-b^2}{2}\cos 2\theta}+\sqrt{\frac{a^2+b^2}{2}-\frac{a^2-b^2}{2}\cos 2\theta}.$$

Now the condition which renders P a minimum also makes P^2 a minimum.

$$P^2=a^2+b^2+2\sqrt{\frac{(a^2+b^2)^2}{4}-\frac{(a^2-b^2)^2}{4}\cos^2 2\theta}$$

which is a minimum when

$$\frac{(a^2-b^2)^2}{4}\cos^2 2\theta$$

is a maximum. This value is a maximum when $\theta=90°$. When this value is substituted in the original, P is found to be $a+b$.

Solutions were also offered by Hugo Brandt, Chicago, Ill., Charles W. Trigg, Los Angeles City College, Los Angeles, Edward C. Varnum, Clyde, Ohio, John Wagner, Chicago, Ill., and also by the Proposer.

1595. No solutions were offered.

1596. *Proposed by Walter R. Warne, Minneapolis.*

Four spherical balls of radius one foot each are arranged in a pyramidal pile. Find the height of the pile.

Solution by A. Mac Neish, Chicago, Ill.

Let P be the plane on which the pile of spheres rests, and let the spheres be tangent to the plane P at the points F, G, and H. The topmost point of the pyramid is E; A, B, C, and D are the centers of the spheres; and r, the radius of each sphere equals 1 foot.

$ABCD$ is a regular tetrahedron the edge of which is $2r$ or 2 feet.

The height of the pyramidal pile of spheres is $2r+x$ where x is altitude of the regular tetrahedron.

If e is the edge of a regular tetrahedron, the altitude is $\sqrt{6}e/3$.

So in this case

$$x=\frac{2\sqrt{6}}{3}\text{ ft.}$$

Therefore

$$2r+x=2+\frac{2\sqrt{6}}{3}\text{ or } 3.633\text{ ft.}$$

The height of the pyramidal pile of spheres is 3.633 ft.

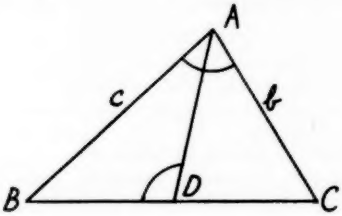
Solutions were also offered by O. L. Dunn, Vincennes, Ind., Arthur Danzl, Collegeville, Minn., W. R. Smith, Chicago, Ill., W. M. Fishback, Sacramento, Calif., Joseph B. Waller, Boyd, Minnesota, Jeanne O'Conner, Calumet City, Ill. C. C. McCauley, New York, Charles W. Trigg, Los Angeles, Kenneth P. Kidd, Gainesville, Florida, James A. Lemon, Eaton, Ohio, Garland D. Kyle, Knoxville, Tenn., and also by the proposer.

1597. *Proposed by William Taylor, Port Arthur, Texas.*

Show that a triangle may be constructed, given two sides and such that the included angle is equal to one of the angles formed by the third side and the median to that side (third).

Solution by John P. Hoyt, Cornwall, N. Y.

In the figure, let b and c be the given sides and let angle BAC equal angle BDA, AD being the median.



Triangle BAC and triangle BDA are similar since they have two angles respectively equal. Therefore, $BD/c = c/BC$. But BD equals $BC/2$. Substituting and solving for BC. $BC = \sqrt{2}c$. Hence, BC is the hypotenuse of a right triangle whose legs are each equal to c. Triangle ABC can then be constructed since its three sides are known.

Solutions were also offered by A. Mac Neish, Chicago, Ill., Kenneth P. Kidd, Gainesville, Fla., D. F. Wallace, Edward C. Varnum, Clyde, Ohio, Garland D. Kyle, Knoxville, Tenn., M. Kirk, West Chester, Pa., and also by the proposer.

HIGH SCHOOL HONOR ROLL

The Editor will be very happy to make special mention of high school classes, clubs, or individual students who offer solutions to problems submitted in this department. Teachers are urged to report to the Editor such solutions.

1594. *S. A. G. Singer.*

1596. *D. Bryce Wilson, Upper Canada College, Toronto Ont. Canada.*
S. A. G. Singer.
Jeanne O'Conner, Calumet City, Ill.

PROBLEMS FOR SOLUTION

1610. *Proposed by C. W. Trigg, Los Angeles City College.*

There is a set of five digits whose sum is eight and which has two permutations whose squares contain no duplicate digits. Find the set and identify the permutations.

1611. *Proposed by I. N. Warner, Platteville, Wis.*

How many board feet in a stick 16 ft. long with parallel rectangular ends, one 4 in. by 4 in., the other 2 in. by 2 in.?

1612. *Proposed by John P. Hoyt, Cornwall, N. Y.*

ABC is an equilateral triangle with side 7. D is a point on AB at a distance 2 from B. DE is a line through the centroid of the triangle, E being the point where this line intersects AC. Find the length of EC.

1613. *Proposed by Winfield M. Sides, Andover, Mass.*

Deduce a formula for the angle between two successive ribs of an

umbrella of n straight ribs, if each rib makes an angle of x degrees with the center stick.

1614. *Proposed by Willis Waggoner, Syracuse, N. Y.*

Solve for x and y.

$$\left(3-\frac{6y}{x+y}\right)^2+\left(3+\frac{6y}{x-y}\right)^2=82$$

$$xy=2.$$

1615. *Proposed by Hazel C. Jones, Danville, Ill.*

In the formula for the area of a triangle, $A=\sqrt{s(s-a)(s-b)(s-c)}$, prove that $s(s-c)=(s-a)(s-b)$ if the triangle is a right triangle

---

CORRECTION: For the statement of Problem 1606 in the April issue, the fraction should have been $1/x^{5/6}+1$. Editor.

SCIENCE QUESTIONS

May, 1939
Conducted by Franklin T. Jones

Readers are invited to cooperate by proposing questions for discussion or problems for solution.

Examination papers, tests, and interesting scientific happenings are very much desired. Please enclose material in an envelope and mail to Franklin T. Jones, 10109 *Wilbur Ave. S.E., Cleveland, Ohio. Thanks!*

SNOW IN SUN VALLEY

857. *Proposed by Virgil Henry (Elected to the GQRA, No. 271), Science Instructor, Dexter, New Mexico.*

I wish to apply for membership in your *GQRA* with this question which I have been unable to explain satisfactorily to my Physics class. How is it possible for the temperature to often rise above 90 degrees Fahrenheit in Sun Valley, Idaho and not melt the snow? Perhaps some of your readers can explain this unusual phenomenon.

PROBLEM ON ELECTRON THEORY

858. *Proposed by Eugene Ferraro (Elected to the GQRA, No. 269) student Wellington C. Mepham High School Bellmore, N. Y.*

Sent in by Francis E. Almstead (Elected to the GQRA, No. 268), Co-Chairman Science Dept.

Why does the one electron in the hydrogen atom remain in its orbit when there is only a proton in the nucleus of the hydrogen atom? Why doesn't the one proton in the nucleus attract the one electron to it from the orbit? I can understand, partly at least, why the electrons remain in the different orbits of all other atoms after knowing about the motion of the electrons in the orbits and that there are electrons in the nucleus of other atoms.

COLORS

859. *Proposed by Phyllis Marshall (Elected to the GQRA, No. 272). Dexter, New Mexico.*

What are the primary colors? In our Physics text by Brownlee, Fuller and Baker we find that they are red, blue and green. In the Century Dictionary we find that they are red, green and violet of the spectrum and red, yellow and blue of the pigments. In the Webster Dictionary we find they are red, green and blue-violet. What shall we use?

I would like to know what the difference would be in placing two colors on a wheel and spinning it to make a new color and placing the same proportions of the same colors in pigments and getting a different color than that made by the color cards.

FORCE AND ENERGY

848. *"A Car is Like a Cat."*

James M. Wilbur (GQRA, No. 150) objects to the equating of Kinetic Energy to Force in the answer of Milton Stitzel (GQRA, No. 263). [See SCHOOL SCIENCE AND MATHEMATICS, March, 1939, pages 288–9.]

What is your criticism?

CURRENT IN INDUCTION COIL— PULSATING OR ALTERNATING

845. *Proposed by John Kilpatrick, (GQRA, No. 250) and Basil C. Barbee (GQRA, No. 218), Stephen F. Austin College, Nacogdoches, Texas.*

In an induction coil whose primary is driven by a direct-current source (being interrupted, of course), is the voltage developed across the secondary alternating or pulsating current?"

Answers by C. B. Harrington (Elected to the GQRA, No. 259), Newton High School, Newtonville, Mass., and by Wm. A. Porter (GQRA, No. 148), Chisholm, Minn.

C. B. HERRINGTON:

"Many years ago while teaching physics at Worcester Poly. Institute, a local M.D. brought me an induction coil which he used for medical treatments. It was necessary to have a uni-directional discharge and to know which terminal was +. In studying the problem I discovered the following facts,—

"The discharge from an induction coil is a pulsating discharge but it may be controlled by varying the capacity of the condenser across the spark gap so as to give equal discharges in both directions or an unidirection discharge. I used a special vacuum tube, long and slender (perhaps 15″ long and 2″ in diameter) through the center of which were 2 long slender electrodes with gap of perhaps 1 inch between the ends. When connected to the secondary terminals of the induction coil these electrodes glowed with a bluish light near the ends at the center of the tube. By varying the condenser the lengths of electrodes showing discharge were varied from equal discharges on both to a discharge glow on 1 only, in which case the discharge was unidirectional.

"So evidently both sides of the arguing groups are partly right."

W. A. PORTER:

"I believe that in one sense both parties are correct. Theoretically: An

alternating current should be produced in the secondary of an induction coil. Practically the situation is complicated by a number of factors, the capacity of the condenser, the inductance of the coil, the size and nature of the core and the frequency of the circuit breakers. As is well known a voltage is induced only when there is a change in the magnetic flux and the amount of voltage is determined by the number of lines of force cut in a given time. When the circuit is *made* the primary current builds up slowly because of the reactance of the coil and core and because of the time lost in charging the condenser therefore few lines of force change in a given time and only a feeble voltage is developed in the secondary. But, at the break the whole magnetic field collapses almost instantaneously, and as a result the enormous voltage is generated in the secondary in an effort to sustain the failing primary current. Therefore an x-ray tube would work only on the surges and would have to be connected so that the current went in the proper direction through the tube. Now coils built for x-ray use can be designed to show very little "reverse" current and appear to be generators of a pulsating direct current, and this is probably the case of the coil in the Lab at S. F. Austin College. I hope that this explanation clarifies the situation."

COMMUNITY INTEREST IN SCIENCE

832. *Proposed in October, 1938, S. S & M.*

Answer by Mary Virginia Rogers (Elected to the GQRA, No. 260), Mercy Bio-ite Club, Milwaukee, Wis.

How can we make our community interested in science?

"Most schools have a P.T.A. organization, now known as the Home and School Association. When these meetings are held a program is generally given. I suggest having some of the science students put on a play featuring some famous scientist, or build a program or skit around some scientific fact. Those attending the meeting are interested in the students and no doubt would become interested in science if the program was well given.

Later in the year a program such as the type demanded a year ago by the President of the U. S., namely a Conservation Program, would be not only interesting but instructive even for adults."

DO YOU KNOW THE ANSWERS?

(*Propose questions—short and snappy—for this section of* SCIENCE QUESTIONS. *Classes and teachers are invited.*)

The following questions were all submitted by members of the Mercy Bio-ite Club, Mercy High School, Milwaukee, Wis.

41. Why does not a person get a dent rather than a swelling when he is hit on the head with a heavy object?
(*Proposed by Virginia Delmore, GQRA, No. 275*)
42. What is the most recently discovered vitamin?
(*Betty Russell, GQRA, No. 278*)
43. What is the difference between a crawfish and a crayfish?
(*Rose Wielondek, GQRA, No. 280*)
44. What is fish considered to be a brain food?
(*Mary Scholtz, GQRA, No. 286*)
45. Where shall we apply for true seed of the white as well as the sweet potato? (Our State Department of Agriculture can not assist us.)
(*Lorraine Poplaczyk, GQRA, No. 288*)

ANSWERS

31. Add *two* figures to 41 and get $4\frac{1}{2}$ which is *less* than 41.

32. The famous "Reversing Falls" of Saint John, New Brunswick.

(*Answered by Principal Karl F. Keirstead, B. A., Saint Andrews Public Schools, Saint Andrews, New Brunswick*)

"While I am not a native of the foggy city, having been born in the Union of South Africa, yet I learned to swim in an old scow at the foot of those same falls. And is the Fundy water cold! Jump in on the hottest day in summer and you'll receive the greatest shock of your life. That is because the very high tides, 'stir everything from the lowest depths,' as Virgil says.

"In spite of the chilling water, St. Andrews has managed to achieve and maintain its position as the Newport of Canada by its bathing beach at Katy's Cove. A small cove into which a small brook runs has been dammed by gates low enough to admit salt water at high tide. The enclosed water is shallow enough for the sun to warm and the water may be changed at every high tide, if desired. In the winter the natives skate on the half-salt water. Only an unusual winter will freeze ice in the bay—again the work of the high tides.

"Another gift of the high tides is '*The Road on the Floor of the Ocean*.' The island estate of the late Sir William Van Horne becomes a peninsula at low tide. Thus the fairly good road on the bar is covered by 10 to 20 feet of water at high tide. Some pupils to this school who live there, are very irregular in their attendance when the tides are not right.

"I am wandering from the Saint John river. The Fisheries regulations count the waters of the river up to 15 miles above Fredericton (look it up on the map) as tidal waters. I understand that only one other river in the world (in France?) has a delta so far from its mouth. Beginning at the tidal waters, the grass lands on either side of the river and on the islands are extremely fertile due to the annual spring floods that deposit the rich layer of mud. This same flood often piles up cakes of ice that carry away barns, bridges, etc. Usually the ice runs out in April or even March, but I recall one year when the May-pole was planted on the solid ice the first day of May. The ice ran the next day. However, if you came to Canada in the summer, do not bring snowshoes like some of your countrymen. Our summers here are almost as hot as yours; except down by the sea, where we get the sea breeze.

"These Spring Floods in the river bring about certain changes in the Saint John Harbor below the Reversing Falls. The change in salinity, for instance, caused by the extra amount of fresh water kills off the parasites that attack the wharves and piling. This discovery, made by an investigator attached to the Biological Station at St. Andrews, saved the Dominion Government half a million or so. (A practical example of the applied results of pure science). When new wharves were being built, it was thought that the piling should be especially treated to protect it against the action of marine parasites. The above investigation revealed that such special treatment was not necessary."

33. A fish becomes "furbearing" when sea weed grows on him to look like fur.

34. Charlie Maltbie, Village Marshal at Geneva, Ohio, had a pet ground hog but says he never came out from hibernation until long after February 2nd.

35. "Voder" is the machine that talks like a man, duplicating the human

throat. (*Life*, p. 24, Jan. 30, 1939.) The voder consists of a keyboard and instrument panel, an amplifier and a loud speaker. By punching keys the operator can make words and sentences.

JOIN THE GQRA

Submit an answer; propose a question; classes and teachers invited to join.

New Members—May, 1939.

No. 268. Francis E. Almstead, Wellington C. Mepham High School, Bellmore, N. Y.
269. Eugene Ferraro, student, Bellmore, N. Y.
270. Karl F. Keirstead, B.A. Saint Andrews, New Brunswick.
271. Virgil Henry, Science Instructor, Dexter, New Mexico.
272. Phyllis Marshall, Dexter, N. M.

From Mercy Bio-ite Club, Mercy H. S., Milwaukee, Wis.

273. Elizabeth Harvey
274. Thomasine Welch
275. Virginia Delmore
276. Virginia Varley
277. Marion Megal
278. Betty Russell
279. Dorothy Quinn
280. Rose Wielondek
281. Frances Kubar
282. Helen Conway
283. Dolores Hillebrand
284. Erna Micko
285. Rita R. McGraw
286. Mary Scholtz
287. Bernice Pagenkopf
288. Lorraine Poplaczyk
289. Betty Ann Fay

BOOKS AND PAMPHLETS RECEIVED

Higher Mathematics, by Richard Stevens Burington, Assistant Professor of Mathematics, The Case School of Applied Science, Cleveland, Ohio, and Charles Chapman Torrance, Instructor in Mathematics, The Case School of Applied Science, Cleveland, Ohio. Cloth. Pages xiii+844. 14.5×23 cm. 1939. McGraw-Hill Book Company, 330 W. 42nd Street, New York, N. Y. Price $5.00.

The Decline of Mechanism in Modern Physics, by A. d'Abro. Cloth. Pages x+982. 15×23 cm. 1939. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $10.00.

Psychology and Teaching of Secondary-School Subjects, by Homer B. Reed, Professor Psychology, Fort Hays Kansas State College, Fort Hays, Kansas. Cloth. Pages xviii+684. 13.5×20.5 cm. 1939. Prentice-Hall, Inc., 70 Fifth Avenue, New York, N. Y. Price $3.25.

The Microbe Man, A Life of Pasteur for Young People, by Eleanor Doorly, Author of "The Insect Man." Cloth. Pages xiii+160. 13×20.5 cm. 1939. D. Appleton-Century Company, 35 W. 32nd Street, New York, N. Y. Price $1.50.

Number: The Language of Science, by Tobias Dantzig, Professor of Mathematics, University of Maryland. Third Edition, Revised and Augmented. Cloth. Pages x+320. 14×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $3.00.

Farm Management, by Robert R. Hudelson, College of Agriculture, University of Illinois. Cloth. Pages x+396. 13.5×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.80.

Agriculture and Farm Life, by Harry A. Phillips, Ph.D., Head of Agriculture and Biology, Edgar A. Cockefair, Professor of Biology, and James W. Graham, Associate Professor Agriculture, All of the State Teachers College, Warrensburg, Missouri. Cloth. Pages xiii+496. 14×21.5 cm. 1939. The Macmillan Company, 60 Fifth Avenue, New York, N. Y. Price $1.48.

Exploring the World of Science, by Charles H. Lake, Superintendent of Public Schools and Formerly Principal of East Technical High School, Cleveland, Ohio; Henry P. Harley, Supervising Teacher of Science, Fairmount Junior High Training School, Cleveland, Ohio; and Louis E. Welton, Assistant Principal and Formerly Head of Science Department, John Hay High School, Cleveland, Ohio. Cloth. Pages ix+710. 14×20.5 cm. 1939. Silver Burdett Company, 45 East 17th Street, New York, N. Y. Price $1.80.

Deserts, by Gayle Pickwell, Professor of Zoology at San José State College, California. Cloth. Pages xiv+174. 22.5×29 cm. 1939. Whittlesley House, McGraw-Hill Book Company, 3330 W. 42nd Street, New York, N. Y. Price $3.50.

Understanding our Environment, by John C. Hessler, President, James Millikin University, Sometime Instructor in the High Schools of Chicago, and Professor in Knox College, and Henry C. Shoudy, Teacher of Science, North High School, Syracuse, New York. Cloth. Pages ix+661. 13.5×20.5 cm. 1939. Benj. H. Sanborn and Company, 131 Clarendon Street, Boston, Mass.

The Teaching of Science in Elementary and Secondary Schools, by Victor H. Noll, Associate Professor of Education, Michigan State College. Cloth. Pages viii+238. 13.5×21.5 cm. 1939. Longmans, Green and Company, 114 Fifth Avenue, New York, N. Y. Price $2.00.

Activities in General Science, by Samuel P. Unzicker, Department of Physical Sciences, New Jersey State Teachers College, Paterson, N. J., and Benjamin C. Gruenberg, Lecturer on the Philosophy of Science, College of the City of New York. Paper. Pages vi+202. 19×26.5 cm. 1939. World Book Company, Yonkers-on-Hudson, N. Y. Price 68 cents.

Experiences in Physics, by Lester R. Williard, Thomas Jefferson High School, Elizabeth, New Jersey with the Assistance of Charles S. Winter, Thomas Jefferson High School, Elizabeth, New Jersey. Cloth. Pages x+662. 15.5×23 cm. 1939. Ginn and Company, 15 Ashburton Place, Boston, Mass. Price $1.92.

College Biology, by Walter H. Wellhouse, Professor of Biology, Iowa State College, and George O. Hendrickson, Assistant Professor of Zoology, Iowa State College, Second Edition. Cloth. Pages viii+391. 13.5×21.5 cm. 1939. F. S. Crofts and Company, Inc., 41 Union Square, West, New York, N. Y. Price $3.00.

A Contribution to The Biology of North American Vespine Wasps by Carl D. Duncan, Professor of Entomology and Botany, San José State College, San José, California. Paper. 272 pages. 17×25.5 cm. 1939. Stan-

ford University Press, Stanford University, California. Price: cloth $2.50, paper $3.25.

The Development of Power, by Eugene C. Wittick. Paper. Pages xiv+164. 15×23 cm. 1939. The University of Chicago Press, 5750 Ellis Avenue, Chicago, Ill. Price $1.00.

Outline of the History of Mathematics, by Raymond Clare Archibald, Professor of Mathematics, Brown University. Fourth Edition revised and enlarged. Paper. 66 pages. 15×23 cm. 1939. The Mathematical Association of America, Inc., Oberlin, Ohio. Price 50 cents.

Education for Traffic Safety. Lester K. Ade, Superintendent of Public Instruction. Bulletin. 390. 23 pages. 15.5×23 cm. 1939. Commonwealth of Pennsylvania, Department of Public Instruction, Harrisburg, Pa.

Organization and Administration of Public Education, by Walter D. Cocking, Dean of the College of Education, the University of Georgia, and Charles H. Gilmore, Formerly Director of Research in the Tennessee State Department of Education. Staff Study Number 2. Paper. Pages ix+183. 15×23 cm. 1938. Superintendent of Documents, U. S. Government Office, Washington, D. C. Price 20 cents.

BOOK REVIEWS

Introductory College Physics, by Oswald Blackwood, Professor of Physics, The University of Pittsburgh. Cloth. Pages xiv+487. 14.5×23 cm. 1939. John Wiley and Sons, Inc., 440 Fourth Avenue, New York. N. Y. Price $3.50.

A first glance at this book shows that it is somewhat out of the ordinary. It has less than 500 pages while many of the standard texts have 600 to 800 pages In the preface the author states certain steps in his plan: The book is devised to meet the needs of a non-technical course; the student's interest must be aroused, he must be guarded against discouragement in the first few weeks; important concepts are introduced one at a time, difficult topics are deferred until there is need for them A careful examination of the text shows that in the main the author has been guided by principles, but some exceptions occur We find that some of the more difficult concepts such as the composition and resolution of forces, torque, and machines occur in the early chapters, while the mechanics of fluids—a much easier topic—is discssed several chapters further on after the treatment of acceleration, curvilinear motion, energy, and momentum.

The language is simple and clear, the approach is interesting, the illustrations are excellent and accompanied by legends that explain. The use of mathematics is reduced to a minimum. While much that is usually found in general physics texts has been omitted, it contains all the essential principles. Teachers who want a text that gives detailed descriptions and exacting explanations will not favor this text, but those who feel that their pupils are confused by elaborate explanations and rigid proofs will endorse it. Teachers in the liberal arts colleges should examine this text before making an adoption.

G. W. W.

Photography Principles and Practice, by C. B. Neblette, Counselor and Administrative Head, Department of Photographic Technology,

Rochester Athenaeum and Mechanics Institute. Third Edition. Cloth. Pages xi+590. 15×23 cm. 1938. D. Van Nostrand Company. Inc., 250 Fourth Avenue, New York, N. Y. Price $6.50.

Very few textbooks on photography are available and most of them are inadequate. Photography handbooks and manuals are more numerous. The first edition of this book, appearing in 1926, was a pioneer in the sense that it combined both the theory and practice of photography in a volume adapted for textbook use. The third edition gives a brief history of the development of photography, describes the various types of cameras and their characteristics, includes a short section on optics, and describes in detail all the methods and processes used in photographic work. Many photographs, carefully made diagrams, valuable charts and complete formulas supplement and clarify the descriptions and directions. The book is indispensable where courses in photography are given and is a valuable reference for professional and amateur photographers. Some knowledge of physics and chemistry is presupposed. A brief treatment of the processes and materials of color photography gives the essence of this rapidly developing science and indicates the necessary steps and difficulties encountered in acquiring proficiency in in the art.

G. W. W.

Your Automobile and You, by Roy A. Welday, Instructor in Physics and Automobile Driving, Scott High School, Toledo, Ohio. Cloth. Pages xiii+251. 113×19.5 cm. 1938. Henry Holt and Co. New York, New York. Price $.88.

Safety Education is rapidly being recognized as an important phase of general education and it is often given a definite place in the curriculum. Most safety executives, gravely concerned over the steadily mounting toll of injuries and deaths resulting from automobile accidents and the appalling lethargy of the general public in regard to this cause of death and injury, are turning to the younger and more impressionable group of the population and hope by educative means to reduce this wholly unnecessary slaughter.

Your Automobile and You was written to serve as a basic text in secondary school courses designed to give some effective training to the future driver of America. The book presents a brief "History of the Development of the Automobile," a careful analysis of the more essential parts of the automobile, a chapter on the proper care and maintenance of motor cars, and a discussion of the physical factors influencing good driving. It also includes sections on "Automobile Physics," "The Psychology of Driving," "The School of the Driver," "Customs and Rules of the Highway," and "Traffic Laws." The theory and operation of Automobile Insurance is fully discussed along with the cause of auto accidents and factors to consider when buying a car. A chapter on Highways, and one on "Driving as an Art," followed by an extensive study guide complete the book. Provision is made in the study guide for both long and short courses along with directions for the construction of training apparatus.

Teachers of General and Physical Science will find, in the book, much material of practical nature which they can use in making their courses functional in the promotion of highway safety.

W. A. Porter

Physics Made Easy, by Louis T. Masson, M. Ed., Riverside High School, Buffalo, N. Y. Edited by Jean F. Piccard, Doctor of Natural Science and Professor of Aeronautical Engineering, University of Minnesota.

Cloth. 384 pages. 14×20 cm. 1938. W. Hazleton Smith, Buffalo, New York.

In this volume, the author has departed boldly from the setup usually found in physics texts. This departure is not so marked in the organization as it is in the treatment of the topics. The organization closely follows standard practice in dividing the course into fourteen common units, under the following headings: Fundamentals of Physics, Forces, Fluids, Motion of Bodies, Work and Machines, The Nature of Heat, Transformations of Heat Energy, Sound, Introduction to Electricity, Fundamentals of Current Electricity, Effects of Current Electricity, Fundamentals of Light, Refraction and Color Phenomena and Safety. These units are covered in thirty-one chapters.

The treatment, however, emphasizes concepts and applications while minimizing discussion and extensive problem drill. This is accomplished without loss of clarity by the unusual nature of the illustrations. These are so dynamic and so expressive that detailed explanation is unnecessary.

The language is simple, the approach is direct, and the small size is a distinct advantage in a textbook. The book should be very useful in classes that find standard texts too difficult and too extensive in their scope, and will be a welcome addition to the teacher's reference library.

W. A. PORTER

Analytic Geometry, by Roscoe Woods, Associate Professor of Mathematics, University of Iowa. Cloth. Pages xiii+294. 14×22 cm. 1939. The Macmillan Company, New York. Price $2.25.

This is a new kind of Analytic Geometry in several respects. The first noticeable difference from the usual type of text is the very large number of exercises and problems. The first list of sixteen exercises is on page 3; the second list of eighteen is on page five; the third list of fourteen is on page eight, etc. The plan is to keep the student's practice intimately associated with the theory so that he learns always by practicing the applications of the principles presented. Another departure from the usual procedure in many texts is the early introduction of certain topics that are usually presented rather late in the course. Among those that are early introduced are the general equation of the locus of a point, the early discussion of tangents and normals, and the early introduction of the ideas of angle of inclination and slope. Another feature is the introduction of direction angles and direction cosines as applied to plane geometry. The problems are of varied degrees of difficulty so that they can be adapted to the different degrees of ability of different classes and individuals. The book includes three chapters on solid analytic geometry.

WALTER H. CARNAHAN, Shortridge High School, Indianapolis

Business Mathematics, by Isaiah Leslie Miller, late Professor of Mathematics, South Dakota State College of Agriculture and Mechanic Arts, and Clarence H. Richardson, Professor of Mathematics, Bucknell University. Cloth. Pages xii+352. 14×24 cm. 1939. D. Van Nostrand Company, Inc., 250 Fourth Avenue, New York, N. Y. Price $3.75.

This is not a commercial arithmetic, nor a book of rule-of-thumb procedures for the behind-the-counter sales person, but a book to give real comprehension of the principles of business accounting. The text makes free use of Algebra and introduces algebraic principles which are somewhat out of the range of the usual course in high school algebra as generally presented. The book is planned to be used in a college course but might

be suitable for use with an advanced high school class. Mastery of the book would require a full year.

The first 92 pages are devoted to a very thorough and carefully presented review of elementary algebra through quadratics. Then follows a chapter on percentage, then interest and discount, compound interest and compound amount, annuities, sinking funds, depreciation, valuation of bonds, probability as applied to life insurance, and other advanced topics. Reviews and very complete tables close the book.

Every topic is presented with as few assumptions as possible as to the extent of previous knowledge. There are many carefully worked examples and clear discussions. The problems range from the most elementary to these that are of such a degree of difficulty as to test the best pupils. Type and format of the book are very attractive.

WALTER H. CARNAHAN, Shortridge High School, Indianapolis

The Structure of Economic Plants, by Herman E. Hayward, Professor of Botany, University of Chicago. Cloth. Pages x+674. 16×24 cm. 339 pages with illustrations. 1938. Macmillan Co., New York. $4.90.

This is an outstanding book in its field. The author has brought together into one volume valuable material which heretofore existed only in scattered monographs and special papers. The book is divided into two parts. Part I has to do briefly with the presentation of the developmental anatomy of the plant (angiosperms) presenting the nomenclature which is used in part II. This is necessary because the nomenclature is not consistent in this field, to still further clarify the situation a special glossary is appended. In part II the morphological and exhaustive anatomical aspect of the following types of economic plants are given namely: Family Gramineae (grass), Zea (corn) and Tricum (wheat). Lillaceae, Allium (onion). Moraceae, Cannabis (hemp). Chenopodiaceae, Beta (beet). Cruciferae, Raphanus (radish). Leguminosae, Medicago (alfalfa) and Pisum (pea). Linaceae, Linum (flax). Malvaceae, Gossypium (cotton). Umbelliferae, Apium (celery). Convolvulaceae, Ipomoea (sweet potato). Solanaceae, Solanum (white potato), and Lycopersicum (tomato). Cucurbitaceae, Cucurbita (squash). Compositae, Lactuca (lettuce). Besides being a welcome addition to the work in the fields of graduate and applied botany this book has an unusually fine mechanical makeup.

A. G. ZANDER

A Laboratory and Field Guide to Biology, by Samuel H. Williams, Professor of Zoology in the University of Pittsburgh and Associate Director of the University Lake Laboratory. Cloth. Pages xxv+130. 11×15 cm. 1938. Macmillan Company New York. Price. $1.25.

This laboratory manual is designed to be used from the natural history viewpoint rather than from that of the type and principle angle. There are no exercises on dissection in this book. The aims of this book as stated by the author are: to develop an understanding of and an interest in the living world about us, to supply a wholesome recreation and to interestingly fill leisure hours and to contribute to intellectual happiness.

The book is admittedly written for those who go no farther into this field than as hinted above. The book therefore covers these aspects of this field: general structure, activities, associations and classification of living things. There are 65 exercises. 9 on invertebrates, other than the insects, 8 on insects, 6 on vertebrates, 20 on associations, 2 on coloration and mimicry, 17 on plants, 2 on special directions, 1 on classifications. A col-

lecting chart and a good reference on equipment and methods appear in the fore part of the book.

A. G. Zander

Lasius, The Lucky Ant, by Nina A. Frey. Illustrated by Alma W. Froderstrom. Cloth. 95 pages. 15×21.5 cm. 1938. E. P. Dutton & Co., Inc., 300 Fourth Avenue, New York, N. Y. $1.50.

The first-born worker in the nurseries of an ant queen, Lasius is early forced to work, not only for her own food, but in order to care for the queen mother and for the rapidly increasing supply of eggs in the underground nursery. For the first weeks of her life—from egg, to larva, then to pupa, and even after she emerges from the cocoon, Lasius is fed by the queen mother, even if it means eating some of the eggs. Next it is Lasius' turn.

The author tells, in sequence, how Lasius first leaves the nest in search of food. Finding the plant aphids or ant cows do not solve her problem; they too must be protected. Dangerous encounters with a mole, a woodpecker, and a spider, as well as a miraculous escape from certain death in the pit of an ant-lion prove that Lasius is truly a lucky ant.

The growing family brings not only the problem of feeding the young and caring for the eggs, but also entails the guarding of the nursery from danger. Most realistically, Miss Frey tells of Lasius' returning to the nurseries upon one occasion to find the nest invaded by ant-eating beetles, whose liquids cause the ants to shower them with attentions and to fall asleep. Soon the ants, in a frenzy of hatred and revenge, destroy their guests. All goes well, as summer comes to an end. Lasius, in her search for food, comes upon earthworms, caterpillars, flies, and butterflies, busy about their daily activities.

One day Lasius returns to the nest to find all the sisters, eggs, and cocoons gone. Feeling her way into the lower rooms, she discovers the queen and a few of the sisters, sole survivers of a raid made by red slavemaker ants, who had come in search of workers.

A quiet winter, and then spring again; and as new winged males and future queens are born, the exciting story of the ant colony, as so humanly and interestingly told by Miss Frey, is begun once more.

Jane Howard, National College of Education

Children of the Golden Queen, by Flora McIntyre, Cloth. Pages iv+80. 19×23 cm. 1938. E. P. Dutton & Co., 300 Fourth Avenue, New York, N. Y. Price $1.50.

This delightful story tells of the life of bees in great detail. The story progresses from the swarming of the bees through the stage of the birth of a new queen bee, her flight and mating and work laying eggs to the hibernation in the winter cluster, in thrilling sequence. The author is well acquainted with the habits of bees as she herself is a beekeeper and has supplemented her knowledge with research. The book contains very fine pictures illustrating the various types of bees and showing scenes both outside and inside real beehives. The book is as entertaining as a fairy tale but it has the advantage not only of being scientifically accurate but of leaving that impression with the reader. The book is sufficiently simple for third graders to understand if it were read to them and yet scientific enough to interest the junior high school age.

Ruth Hall, National College of Education

Investigations of Vocabulary in Textbooks of Science for Secondary Schools by Francis D. Curtis, Professor of Secondary Education and of The Teaching of Science, University of Michigan. Cloth. Pages viii+127. 15×23 cm. 1938. Ginn and Co., Lithographed, $1.40.

This report gives the summaries of one hundred investigations of the vocabularies of thirty textbooks in secondary school science. This large number of investigations has made available a valuable quantity of statistical information for improving science textbooks. The report is divided into five parts:

(1) Importance of Vocabulary Stu.:y and Difficulties of Vocabulary Study.

(2) Study of Pupil Comprehension of Words in Context.

(3) Determination of the Vocabulary Levels at which High School Pupils Encounter Marked Difficulty in Comprehending Textbooks of Science.

(4) Investigation of Vocularaby Difficulty in Textbooks of High School Science.

(5) Determination of Scientific Terms Which Should Constitute the Glossaries of High School Science Textbooks.

Thorndike's Teachers' Word Book of 20,000 words was used as the standard for the vocabulary study.

Some conclusions which may be drawn from these investigations:

(1) Pupils of junior high school level have more difficulty with non-scientific terms than with scientific terms.

(2) Pupils of senior high school have as much difficulty with scientific as with non-scientific terms.

(3) Most textbooks include more new words than pupils can learn with a reasonable amount of effort. The vocabularies are too difficult for the pupils for whom they are intended.

(4) Too few science textbooks define the scientific terms they use.

(5) The provision for repetition is inadequate.

The report also gives a complete bibliography of investigations on vocabulary study.

IRA C. DAVIS

Third Digest of Investigations in the Teaching of Science, by Francis D Curtis, Professor of Secondary Education and of the Teaching of Scienee, University of Michigan, Ann Arbor, Michigan. Cloth. Pages xvii + 419. 13×19.5 cm. 1939. P. Blakiston's Son and Company, Inc. 1012 Walnut Street, Philadelphia, Pa. Price $3.50.

This book follows the same plan as Volumes I and II of the series published respectively in 1926 and 1931 and covers investigations reported during the years 1931 to 1937. It includes digests of the published reports and of unpublished theses. In selecting the investigations of most value the author was guided by the report on an evaluation sheet sent to the members of the National Association for Research in Science Teaching. This volume is comprised of five digests in the teaching of science in the elementary school, seventy-four at the secondary school level, and sixteen from the college field. The digests in the secondary school section are subdivided by subjects: namely, general science, biology, physics, chemistry, and those of a general nature. In addition to the digests a supplementary bibliography is given for each category. This feature adds much to the value of the book for all students and teachers of science teaching. In putting out this series the author and publishers are making a contribu-

tion of inestimable value. The literature in this field has become so extensive that an instructor of a course in the teaching of science is confronted with the almost impossible task of selecting material and making it available to his students. The three books in this series perform this labor and supply in condensed and practical form the textual material for the course or the basic study preliminary to starting an investigation. No student or teacher of education in science can afford to be without these books.

G. W. W.

Survey of Physical Science, by Paul McCorckle, Porfessor of Physics and Physical Science, State Teachers College, West Chester, Pennsylvania. Cloth. Pages xiii+471. 14.5×21.5 cm. 1938. P. Blakiston's Son and Company, Inc., 1012 Walnut Street, Philadelphia, Pa. Price $2.75.

This book furnishes material for a three-hour course each semester of the freshman college year or may be given "without loss of continuity," in a shorter time by omission of certain chapters. The subject matter is distributed approximately as follows and in the following order: Astronomy six chapters, geology three, meteorology two, physics eight, chemistry six. For the shorter course the chapters omitted are two from geology, one from physics—sound, four from chemistry. The book is well written and illustrated, is unusually free from erroneous or misleading statements for a first edition, and contains good teaching helps such as references, questions, outlines, and suggestions for laboratory work. The text holds closely to basic science, which it presents in as simple and brief a manner as possible. Many teachers may feel that entirely too little has been included but it merits the consideration of all schools especially those requiring a survey of physical science by many students who have had a minimum of science in the secondary school.

G. W. W.

Mineral Tablets, by Arthur S. Eakle, Late Professor of Mineralogy, University of California. Third Edition. Revised by Adolf Pabst, Associate Professor of Mineralogy, University of California. Cloth. 73 pages. 14.5×23 cm. 1938. John Wiley and Sons, Inc., 440 Fourth Avenue, New York, N. Y. Price $1.50.

The value of this book has been proven by constant use for thirty-five years. Identification of minerals in the field by their physical properties is of great value to the professional mineralogist, the collector, and the amateur who studies minerals for recreation. Although the method has its limitations it is often sufficient. The tables are arranged in the form of a key making identification in many cases a rapid process by observation of color, streak, luster, hardness, crystal form, cleavage, and approximate specific gravity. A streak test so directs the observer that his further analysis is confined to a very few pages of the tables which group the minerals according to color and show all the principal physical properties in parallel columns. About two hundred minerals are included. All collectors and students of mineralogy should have this manual.

G. W. W.

When you change address be sure to notify Business Manager W. F. Roecker, 3319 N. 14th Street, Milwaukee, Wis.

MOTION PICTURE REVIEWS

Mysteries of Snow. Bray Pictures Corp., 729 Seventh Ave., New York City. Sale $16. May be rented from: Films of Commerce Co., Inc., 21 West 46th St., New York City. 16 mm., silent, about 2/3 reel.

I. *The Story of the Film.*

This is an old film which shows the different forms of snow crystals. Only in one sequence where animated diagrams are used to show how snow crystals are formed, are motion picture dynamics used effectively.

II. *Criticism of the Film as a Teaching Aid.*

Photographs or lantern slides could be used to show the variety of crystal form more advantageously than does this film. In fact we have here an almost perfect example of subject-matter that should not be presented by means of motion pictures.

III. *Technical Qualities of the Film.*

The landscapes and drawings of snowflakes are adequately done from a technical point of view but they have been shot as stills and consequently lack motion picture interest and artistry. Tilting tends to be too flowery and there are occasional inaccuracies in content.

IV. *Rating.*

1. Age level: grades 8–12.
2. Quality of photography: Not bad as still photography.
3. Selection of scenes: Extremely poor and with little understanding of the motion picture medium.
4. Quality of captions: Tend toward the sentimental.

One-Celled Animals—Protozoa. Eastman Teaching Films, 343 State Street, Rochester, N. Y. 1¾ reels, 16 mm., silent. Sale: reel 1 $24; reel 2 $18.

I. *The Story of the Film.*

The Eastman Company has produced a rather excellent film dealing with the life processes of some common Protozoa as observed and recorded by photomicrography. The film is divided into six units as follows:

a. The nature of a protozoan is shown using an ameba as a typical example. The ameba is dissected under the microscope and all the essential parts of this single-celled animal are clearly shown.
b. Typical movements of protozoa are next illustrated using Condylostoma, Exuviella, and Actinophrys.
c. Food-getting and ingestion are shown here, using the Condylostoma, Paramecium, Blepharisma, and Ameba. The scenes involving Ameba are particularly good, clearly showing the method by which this one-celled animal surrounds and engulfs its food materials.
d. Reproduction follows in the next group of scenes, showing binary fission, conjugation and the formation of cysts. Blepharisma, Spirostimum, and Actinospherium are used to illustrate these activities.
e. Next are shown the methods by which wastes are eliminated. The contractile vacuoles of the Actinospherium, Blepharisma and Paramecium are clearly shown in operation.
f. The final scenes are devoted to the study of the reactions of proto-

zoans to the environment. Here are shown the mucilaginous and sand cases built by some protozoans for protection, the work of others in the intestines of termites, and the contractile responses of protozoa to various stimuli.

II. *Criticisms of the Film as a Teaching Aid.*
The film would be of decided value to those high school and college biology classes that study protozoa in detail. The point-of-view of the film is not always completely clear. In use, the teacher should make clear that the various protozoans are being used to illustrate processes common to all members of this group, rather than in an attempt to study any one class or type exhaustively.

III. *Technical Qualities of the Film.*
This film represents the best technical job involving the use of photomicrography with motion pictures that the reviewing group has seen. The photography is uniformly good, the clarity of objects and scenes is generally excellent. The subject of the film is well adapted for presentation in a motion picture film. A judicious increase in the use of explanatory captions would help the teaching value, as would the use of pointers in many places. The film is printed on an amber base which is regrettable for many reasons. The use of a clear base would increase the illumination and the clarity of many scenes. It would also permit a finer gradation from black to white. This is important when objects are naturally colored. Blepharisma, for example, is pink and all notion that this protozoan may be different in color from the others is lost when the film is printed on an amber base. When purchasing this film, the clear base should be specified.

IV. *Rating.*
1. Age level: Senior high school and college.
2. Quality of photography: excellent.
3. Selection of scenes: Good.
4. Quality of captions: Good, but more of them are needed to make the film clearer to the observer.

Color Changes in Animals. Rutgers Films, New Jersey Hall, Rutgers University, New Brunswick, N. J. 1 reel 16 mm., silent. Sale $25; rent $4.

I. *The Story of the Film.*
The film shows how the various changes in color that certain animals undergo when placed against different backgrounds are due to responses within the animal. In this particular film amphibians, represented by frogs, and crustaceans, represented by the shrimp, are the only animals considered. According to the film these color changes are due to the movement of chromatophores present in certain layers of the skin. The animals can be induced to change their color in the laboratory by changing their background and also by the use of certain experimental procedures which are explained in the film.

II. *Criticism of the Film as a Teaching Aid.*
This film is technical and limited in the group to which it would appeal. For college zoology classes, or for individuals particularly interested in protective coloration, the film would probably be of considerable value. The film is quite detailed but there is inadequate explanation with reference to auxiliary movements (e.g., blood

circulation) which tend to distract attention from the main movements to be watched.

III. Technical Qualities of the Film.

The photographic job done in this film is adequate. Captions, taken individually, are clear enough, but there are not enough of them to make all parts of the film clear. The film would probably be a better teaching device if the laboratory procedures illustrated were explained by a competent speaker while the scientists were working.

IV. Rating.

1. Age level: College, or advanced high school groups.
2. Quality of photography: Good.
3. Selection of scenes: Good.
4. Quality of captions: Individually good, but inadequate in number.
5. General: A film of unique value and great interest to a limited group.

Reviewing committee
HENRY ALDERFER
N. ELDRIDGE BINGHAM
HUBERT M. EVANS
F. T. HOWARD
ALTON I. LOCKHARD
ROSS WYLER
H. EMMETT BROWN, *Chairman*

A NOTE ON THE USAGE OF SCIENTIFIC TERMS

CECIL B. READ, *The University of Wichita, Wichita, Kansas*

An unfortunate situation sometimes arises when, either through carelessness or through lack of agreement, a term which has a very definite meaning in one field is used in another field in a different sense. Here would seem to be a fertile field for cooperation between those working in the various sciences. If the difficulty is primarily one of the unscientific usage of terms, we as teachers should exert our influence to secure properly written texts and manuals; on the other hand, if the difficulty is one of definition, agreement in the various fields should be sought.

To illustrate by a single example, one might consider the term *pressure*. The following definition is taken from a reputable physics handbook: "Force applied to, or distributed, over a surface; measured as force per unit area." Contrasted with this we find a statement from a calculus text: "The pressure on a surface of given area submerged to a specified depth in a fluid is the weight of the column of the fluid which could be supported by the area." Certainly the second definition is not measuring force per unit area. An analysis of the treatment of the subject of fluid pressure in many elementary calculus texts shows the great majority using the term "total pressure" in a manner which apparently makes it synonymous with "total force." A few use the term force instead of pressure; one book states that for convenience the force exerted by a liquid on a submerged area will often be referred to as the total pressure on the area.

Doubtless several other examples could be found; the point which it is hoped will be raised is not that of argument for one definition or the other, rather it is that with beginning students such confusion of terms is very decidedly not to be desired.

A BIOLOGY COLLOQUIUM

Commemorating the fifteenth anniversary of the establishment of a chapter of Phi Kappa Phi at Oregon State college, a "Biology Colloquium" was held on the college campus March 4 to bring before scientists of the northwest the latest developments in the field of biological research for consideration and discussion. Some 300 persons, including science teachers of high schools and colleges in Oregon and neighboring states, physicians and staff members of the Oregon Medical school and others attended the all-day and evening sessions.

Assisting Phi Kappa Phi in conducting the colloquium were the state college chapters of Sigma Xi and Phi Sigma, honor societies in science and biology. Topics discussed during the day included the preparation of the scientist, genetics in history and as applied to modern plant breeding, plant and animal hormones, neurology, plant viruses, essential constituents of living cells, minerals and vitamins, human pathology, and chemotherapy.

Leader of the colloquium was Dr. Charles Atwood Kofoid, world-famed zoologist of the University of California, who addressed the opening session and the evening banquet. In his evening talk on "Trends in Biological Research," Dr. Kofoid said that biological science in the past has been so busy with the individuality of the organism that it has "almost forgotten that there are bodies, communities, patients and societies." An integrated program of research is necessary, he said, in which the effects on "wholes rather than parts," are considered paramount.

Other visiting scientists appearing on the program were Dr. F. W. Went, professor of plant physiology at the California Institute of Technology; Dr. William F. Allen, Dr. Norman A. David, and Dr. Olaf Larsell, all of the Oregon Medical school at Portland. A large number of state college staff members from the various departments also participated.